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Perception Training of Thai Learners: American English Consonants and Vowels

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PERCEPTION TRAINING OF THAI LEARNERS:

AMERICAN ENGLISH CONSONANTS AND VOWELS

by

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ABTRACT
PERCEPTION TRAINING OF THAI LEARNERS:
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Many studies have revealed that ESL and EFL Thai leaners have difficulty producing and perceiving certain English consonants and vowels. The difficult consonants are /b d g v θ ð z tʃ ɹ l/ (Burkardt, 2005; Francis & McDavid, 1958; Jotikasathira, 1999; Lerdpaisalwong & Park, 2012, 2013; Richards, 1968; Wei & Zhou, 2002). The difficult vowels are /ɪ i ʊ u/ (Richards, 1968; Tsukada, 2009; Varasarin, 2007). Previous studies have showed that laboratory perceptual training using highly variable naturally produced stimuli (HVNP) can improve L2 learners' perceptions (e.g., Lively, Logan, & Pisoni, 1993). Nishi & Kewley-Port (2007, 2008) revealed that such training works even more effectively, with the case of vowel, when both Japanese and Korean L2 learners of English were trained with the fullset (i.e., both easy and difficult segments) of segments investigated, rather than the subset (i.e., only difficult segments) of segments.

This study investigates whether those factors found to be effective in training speech perception together with the training set technique suggested in Nishi & Kewley-Port (2007) also work effectively in training Thai EFLs (N = 32)

with English vowels. In addition to perception training on vowels, this study includes perception training on consonants in two different phonological contexts (i.e., onset and coda) and examines how the training set technique works in training Thai EFLs (N = 61) with English onsets and codas. Patterns of both learners' and segments' improvement are observed and presented. The generalization of the trained perception abilities to new talkers is also demonstrated.

In line with Nishi & Kewley-Port (2007, 2008), the results of the current study show that fullset training worked more effectively in training Thai EFLs with English vowels. The results, therefore, correspond to the findings from the previous studies and suggest that this technique works well in both ESL and EFL contexts. Interestingly, the results showed similar patterns between vowel and consonant training whereby the fullset training also worked more effectively in training Thai EFLs with consonants (i.e., both onsets and codas), although vowels and consonants vary in many respects. This suggests that there is to some extent a relationship between the acquisition of L2/ target-language vowels and consonants (Best and Tyler, 2007; Bohn and Flege, 1997; MacKain, Best, & Strange, 1981). The results also suggest a linkage between productions and perceptions when compared to the study of Burkardt (2005). Importantly, after going through the training sessions, Thai EFLs in every training group could generalize their trained perception abilities to the new talkers.

DEDICATION

To my beloved family

To all of my teachers

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Chapter 1

Introduction

1. Purposes and Significance

1.1 English Listening Problems

Listening is an important skill for both English-as-a-second-language (henceforth ESL) learners and English-as-a-foreign-language (henceforth EFL) learners in order to acquire a target language (Bamford, 1982; Blair, 1982; Boyle, 1984; Gilakjani & Ahmadi, 2011; Krashen, 1995; Murphy, 1987; Palmer, 1917; Rost, 1994; Winitz, 1981). Nevertheless, it is one of many challenging problems for both ESL and EFL learners (Chen, 2005; Ferris & Tagg, 1996; Goh, 2000; Hasan, 2010; Mason, 1995; Murphy, 1987; Ostler, 1980).

A handful of researchers have found that human perception operates in a bottom-up fashion and a lower-level unit (e.g., acoustic phonetic information and a phoneme) must be processed appropriately in order for listeners to build upon a higher-level unit (e.g., lexical access and the key ideas in the message) (Andrew, Blumstein, & Burton, 1994; Goldinger, 1996, 1998; Hintzman, 1986, 1988; Marslen-Wilson, 1985, 1989; Pisoni & Luce, 1987; Roediger & McDermott, 1993; Tenpenny, 1995; Warren & Marslen-Wilson, 1987, 1988). In addition, some researchers have proposed that both forms of processing (i.e., top-down and bottom-up processing) are needed in human speech perception mechanisms (Anderson, 1983, 1995; Andruski, Blumstein, & Burton, 1994; Chen, 2005; Clark & Clark, 1977; Cluff & Luce, 1990; Field, 2003; Fowler, 1986, 1990a, 1990b; Fowler & Rosenblum, 1990, 1991; Goh, 2000; Luce, Pisoni, & Goldinger, 1990;

Nunan, 1998; Palmeri, Goldinger, & Pisoni, 1993; Saricoban, 1999; Wilson, 2003).

The significance of listening skills has been demonstrated in many studies. There is convincing evidence showing that listening instruction is necessary for learners at the early stages of learning a second language (L2) (Bamford, 1982; Blair, 1982, Palmer, 1917; Winitz, 1981). Boyle (1984) contended that the emphasis on listening comprehension at all levels of English language teaching has been increasing worldwide. Gilakjani & Ahmadi (2011) stated that listening is an important skill for daily communication and educational process, since listening takes up the highest percentage in communication among other skills (i.e., speaking, reading and writing). Because of the realization of importance in language learning and teaching in recent years, there has been an increased focus on L2 listening ability. Krashen (1995) contended that listening comprehension gives the right conditions for language acquisition and development of other language skills. Murphy (1987) stated that ESL students need firm control over listening as well as other skills (i.e., reading, writing, and speaking) to ensure their success in college. Rost (1994) also mentioned the importance of listening in second-language instruction. One reason is that listening is an important tool required for any learning to occur because it provides learners with comprehensible input. Another reason is that it is not only important as a receptive skill but in the development of spoken language proficiency, as well.

Nevertheless, the ESL and EFL learners’ listening problems have been revealed in many studies. Chen (2005) studied barriers in acquiring listening strategies for EFL learners and found that listening comprehension obstacles confronted by the learners are multifaceted (e.g., listening habits, information processing capacities, listening strategies, and listening material used), and each facet may cause a comprehension failure. Ferris & Tagg (1996) found that literacy tasks (i.e., listening and speaking tasks) are one of the ESL students' emphasized problems, specifically one significant issue is general listening comprehension (as opposed to lecture comprehension). Goh (2000) contended that all language learners have difficulties listening to the target language. She pointed out that less proficient listeners had more problems with low-level processing. Since the types and the extent of difficulty are different, much listening comprehension research has been conducted to investigate these differences. Hasan (2010) found that EFL learners had a range of listening problems (e.g., difficulty in understanding natural speech and unclear pronunciation and fast speech and lack of understanding in spoken text). Mason (1995) and Ostler (1980) reported that even students with Test-of-English-as-a-Foreign-Language (TOEFL) scores high enough for admission to most U.S. university programs may face linguistic challenges with academic listening. Murphy (1987) stated that the listening problems for ESL learners in ESL comprehension of academic lectures seem different from their problems with other language skills (i.e., reading, writing, and speaking).

Moreover, many studies revealed that human speech perception mechanism proceeds in a bottom-up fashion. Wilson (2003) mentioned two approaches (i.e., a top-down process and a bottom-up process) for teaching EFL listening. He stated that some previous literature in the EFL field focused only on teaching strategies, which are generally top-down processes. However, much psycholinguistic research has provided supportive evidence that the bottom-up process is employed in listening comprehension (Goldinger, 1996, 1998; Hintzman,1986, 1988; Marslen-Wilson, 1985, 1989; Pisoni & Luce, 1987; Roediger & McDermott, 1993; Tenpenny, 1995; Warren & Marslen-Wilson, 1987, 1988). Andruski et al. (1994) stated that listeners are sensitive to acoustic variability and this variability can influence the identification of segments in languages. They also stated that low-level acoustic differences (e.g., tokens with altered Voice Onset Time in their study) could affect speech processing, although subjects judged that the phonetic characteristics of the segments are the same. Marslen-Wilson (1985) contended that human perception operates “bottom up” rather than “top down”, because errors in the sensory input will prevent the comprehensibility of an utterance. Pisoni & Luce (1987) pointed out that many speech perception studies are interested in feature and phoneme perception in highly controlled environments using nonsense syllables. This is an appropriate approach for studying “low-level” auditory and acoustic-phonetic analysis of speech. They discussed and supported the framework which assumes that speech is processed through a series of analytic stages ranging from peripheral auditory processing, acoustic-phonetic and phonological analysis to word recognition and lexical access. Furthermore, the studies of Marslen-Wilson (1989) and Warren & Marslen-Wilson (1987, 1988) showed that fine-structure acoustic details can affect word recognition.

Corresponding to Marslen-Wilson (1985, 1989), Pisoni & Luce (1987), and Warren & Marslen-Wilson (1987, 1988), Goldinger (1996, 1998), Hintzman (1986, 1988), Roediger & McDermott (1993), and Tenpenny (1995) found convincing evidence from their studies that supports that the variable speech signals can be matched to canonical representations in memory and that the detailed episodes (i.e., voice details of spoken words) construct the basic element of the mental lexicon. These processes imply the bottom-up operation in human perception.

Nonetheless, there is no intention here to leave the impression that listening comprehension relies only on a low-level unit. What needs to be highlighted here is that the low-level unit should be taken into consideration if successful listening is needed (Andruski et al., 1994; Cluff & Luce, 1990; Luce et al., 1990). To support this point there are several psycholinguistic models proposed that function as a hybrid model, which is the combination of abstract (i.e., a top-down process) and episodic representations (i.e., a bottom-up process), such as a direct realism theory (Fowler, 1986, 1990a, 1990b; Fowler & Rosenblum, 1990, 1991; Palmeri et al., 1993). Anderson (1983, 1995) proposed three cognitive processing phases related to comprehension problems: perception, parsing, and utilization. At the perceptual processing stage the listener encodes acoustic or written messages. At the parsing stage the listener transforms words into a mental representation, where these words are combined with their meanings. This representation is related to existing knowledge and stored in long-term memory. At the utilization stage the listener retrieves different types of inferences to figure out the interpretation and personalizes it meaningfully, or uses the mental representation to reply to the speaker. Andruski et al. (1994) revealed that low-level fine structure acoustic differences can affect lexical access, at least at an early stage of processing or in a short-lived fashion. The results of their study showed that listeners' reaction times (RTs) became slower when they are primed by tokens with altered VOT with the 50ms interstimulus intervals (ISIs) between the prime word and the target word, but not with the 250ms ISIs. Goh (2000) revealed that at the perception stage, one of the difficulties listeners face is that they do not recognize words they know. At the parsing stage listeners' problems are that they quickly forget what is heard, they are unable to form a mental representation of words they heard. They also do not understand subsequent parts of input because of earlier problems. Subsequently, at the utilization stage they often reported that they understood the words but not the intended message, and they are confused about the key ideas in the message. Thus, these three processes include both "bottom-up" and "top-down" processing. Clark & Clark (1977) also suggested that listening comprehension involves a variety of processes. Hence, it is not plausible to easily tease apart "high" and "low" levels.

In line with Anderson (1983, 1995), Andruski et al. (1994), and Clark & Clark (1977), Field's (2003) study pointed out that many high-level breakdowns of communication are caused by low-level errors. Sometimes second language listeners make a small mistake based on phoneme discrimination. This type of mistake may affect the interpretation of what comes next, and eventually may influence the understanding of a whole text. Nunan (1998) explained that listening is composed of two cognitive processes, the first one is a bottom-up process (data-driven) and the second one is a top-down process (conceptually-driven). The bottom-up processing is to build up meaning from the smallest unit of the spoken language to the largest one in a linear mode. Saricoban (1999) stated that one micro skill embedded in listening is listeners' linguistic competence. Linguistic competence will enable listeners to recognize the formatives of the heard utterance. In other words, it will enable listeners to dissect out of the waveform of the appropriate morphemes, words, and other meaning bearing elements of the utterance, which are low-level units.

Wilson (2003) stated that the listening comprehension requires a bottom-up process in that the initial sound input must be matched against potential 'candidate' words in the mental lexicon. Fowler (1986, 1990a, 1990b), Fowler & Rosenblum (1990, 1991), and Palmeri, Goldinger, & Pisoni (1993) proposed a direct realism theory, which is similar to an exemplar-based theory of the lexicon. This theory explains that the speaker normalization is to perceive words that distinguish invariant phonological information from invariant speaker information (i.e., a top-down process), but the latter information from the memory of a word (i.e., voice details of spoken words and variable speech signal) is still maintained (i.e., a bottom-up process).

The point that should be made clear here is that Anderson's (1983, 1995) three cognitive phases and psycholinguistic research has been developed from the nature of listening, which is based upon first language (L1) research (Murphy 1987). However, it should be able to provide some grounds for understanding second language listening mechanisms. Færch & Kasper (1986) provided convincing arguments that the basic cognitive processes in L1 and L2 comprehension are similar, although L2 language learners apparently experience more linguistic and sociolinguistic constraints. Also, the study by O'Malley, Chamot, & Küpper (1989) has shown evidence, which supported the presence of perception, parsing and utilization in L2 comprehension. Research in acquiring languages with consonant complex clusters revealed that when adult L2 learners received only auditory input, they simplified consonant clusters by omitting consonants rather than epenthesizing, similar to native speaking children do (Young-Scholten, 1995). This also suggests the similarity between L1 and L2 acquisition mechanism.

In summation, ESL and EFL listening problems have been primary concerns of language instructors and linguists for many decades, since it is one of the key factors affecting ESL and EFL learners' successful learning and communication. As has been discussed in this chapter both types of processing (i.e., a top-down and a bottom-up) are involved in human speech perception, a bottom-up process or a lower-level unit (e.g., acoustic phonetic information and a phoneme) is a crucial element that at the very least, needs to be taken into consideration to assure successful listening as it helps listeners achieve a higher-lever unit (e.g., lexical access and the key ideas in the message) effectively.

1.2 Aim of the Study

Based on what has been discussed in Section 1.1, it would be beneficial to offer ESL and EFL learners effective speech perception training in order to strengthen their listening abilities which is necessary for successful learning and communication. Thus, this study aims to investigate an effective perception training method to L1-Thai learners of L2-English. In particular, I compared two speech perception techniques, that is, fullset vs. subset perception training, for both vowels and consonants. Nishi & Kewley-Port, (2007, 2008) reported that the fullset training was more effective for training vowels to Japanese and Korean ESL learners. However, the superiority of the fullset training over the subset training has not been attested in other language learners. Therefore, first, the current study investigates whether such a scenario would be the case for Thai EFL learners, whose L1 vowel inventory (i.e., Thai vowel system) is different from those of the previous studies (i.e., Japanese and Korean vowel systems). Second, the current study examines consonant training in addition to vowels since only vowels were investigated in the previous studies. I incorporate consonant training in two phonological contexts, onsets and codas, since previous studies (Allyn, 2013; Burkardt, 2005; Polka, 1991) have reported that phonological contexts contribute to different degrees of difficulty in learning L2 sounds. Third, this study examines the improvement patterns from two aspects: listeners and segments. This will provide a clear picture on how each technique works. For instance, how a fullset and a subset training works in training different segments (i.e., vowels, onsets, and codas). Finally, I will discuss whether the learners can generalize their vowel and consonant perception abilities to a new talker after going through the training sessions, which is the ultimate goal of any training.

Chapter 2

Background

1. Introduction

This chapter presents factors proved to be effective in speech perception trainings in the previous literature, as well as other issues that need to be taken into consideration when training speech perception. These suggestions will be useful, not only for the current study, but also for the future speech perception trainings. This chapter also presents fundamental phonological features of consonants and vowels in both English and Thai, as well as the differences between vowels and consonants in English. The following influential speech production and perception theories are presented: Speech Learning Model (SLM: Flege, 1995) and Perceptual Assimilation Model-L2 (PAM-L2: Best & Tyler, 2007). SLM and PAM-L2 have been specifically proposed to account for L2 and non-native speech acquisition process. Lastly, studies on production and perception of English sounds by Thai learners are presented.

2. General Methods for Effective Perception Trainings

As explained in Chapter One, in order for a listener to reach the higher-level understanding (e.g., the key ideas in the message) of a target language (e.g., L2) effectively, the perception of the lower-level units (e.g., segments) must be taken into consideration. Additionally, how learners' first language (L1) phonology and second language (L2) phonology interacts is complex. Thus, many studies have been conducted to find the best way for training speech perception.

Logan & Pruitt (1995) pointed out six factors for effective speech perception trainings as follows (See Table 2-1). First, structured, intensive laboratory training successfully improves L2 learners' perception of difficult L2 sounds (Lively, Logan, & Pisoni, 1993; Lively, Pisoni, Yamada, Tohkura, & Yamada, 1994; Logan, Lively & Pisoni, 1991; Lambacher, Martens, Kakehi, Marasinghe, & Molholt, 2005; Logan & Pruitt, 1995; Nishi & Kewley-Port, 2007, 2008; Pisoni, Aslin, Perey, & Hennessy, 1982; Pisoni, Lively, Yamada, Tohkura, & Yamada, 1993; Pruitt, Jenkins, & Strange, 2006; Strange, 1992; Tees & Werkers, 1984).

For example, Nishi & Kewley-Port (2007, 2008) successfully trained Japanese and Korean listeners to perceive American English vowels. These studies showed that after the 9-day training, the fullset training group's identification scores improved more than those of the subset group. Both the fullset and the subset training groups could generalize improvement to the untrained words and the tokens produced by novel speakers. There was no advantage found for the two combined protocols[1] over the fullset-only protocol. And both the fullset and the subset groups maintained their improvement after three months with the observation of sustained non-improvement for one of the combined protocols. Pisoni et al. (1982) used an identification procedure to train a VOT continuum. The results showed that after ten minutes of training, listeners

[1] The first combined protocol is the fullset training for the first 6 days and the subset training for the last 3 days (i.e., 9V-3V). The second combined protocol is the subset training for the first 3 days and the fullset training for the last 6 days (i.e., 3V-9V).

were able to differentiate the synthetic stimuli as belonging to one of three categories: the American English voiced category, the American English voiceless category, or the non-American English prevoiced category. Logan et al. (1991) used an identification task to train Japanese listeners to perceive the [ɹ] and [l] distinction in naturally produced American English words. Subjects were tested in a pretest/posttest design in order to assess what they learned. The results showed that after fifteen days of training, listeners showed a small but reliable improvement. Lively et al. (1993) and Pisoni et al. (1993) also reported similar results. Tees & Werkers (1984) found that thirty to forty days after the training, listeners' abilities to distinguish a non-native contrast remained intact.

Second, the natural speech tokens in several phonological environments spoken by multiple talkers worked effectively in perception training. For example, the study of Jamieson & Morosan (1989) revealed that when using identification of synthesized stimuli with the prototype technique, the effect was smaller than when using natural stimuli in the fading technique reported in Jamieson & Moroson (1986). Logan et al. (1991) showed that such a method was effective in training Japanese learners to perceive the novel (and difficult) contrast. The subjects in this study not only improved their identification (and responded faster) for the words actually trained, but also generalized training to new words containing these sounds, spoken by new talkers. This result is important because subjects trained on a single talker did not show any generalization.

Lively et al. (1993) trained Japanese listeners to identify English /ɹ/ and /l/. Their first experiment is to train the listeners with an identification task with multiple talkers containing the /ɹ/ and /l/ contrasting in initial singleton, initial consonant clusters, and intervocalic positions. The results showed that by using multiple talkers, Japanese listeners improved moderately in the posttest and they could generalize the trained segments to new words produced by a familiar talker and novel words produced by an unfamiliar talker. In their second experiment, a new group of subjects was trained with tokens from a single talker who produced words containing the /ɹ/-/l/ contrast in five phonetic environments. Although subjects' performance improved during the training and in the posttest, they could not generalize their new knowledge to tokens produced by a new talker. This, therefore, implies that multiple talkers provide better results.

Lively et al. (1994) also showed that training of this sort can result in changes in adults' L2 perception that persist over time, which corresponds to the findings of Nishi & Kewly-Port (2007, 2008). (Also see Mochizuki (1981), who reported listeners' high performance for naturally produced tokens of /r/ and /l/ in her study.) Regarding the reason for a superior result using such a method, Pisoni, Lively, & Logan (1994) contended that natural speech acoustic cues are redundant compared to those of the synthetic speech. Nevertheless, each phonetic contrast contains multiple acoustic cues encoded in the speech signal and that helps maintain intelligibility under poor conditions. Pisoni, Nusbaum, & Greene (1985) also pointed out that highly intelligible synthetic speech requires more cognitive processing than natural (native) speech. That was revealed through response latencies in word/nonword classification tasks. Strange (1992) also contended that stimulus manipulation which is thought to support an auditory mode of perception, in fact, did not facilitate and sometimes interfered with learning to perceive the contrast of the stimuli.

Third, identification tasks have been used to investigate cross-language phenomena in both short- and long- term training settings. Logan et al. (1991) posited that an identification task is more suitable for speech perception trainings compared to a discrimination task, which has been used broadly with a cross-language perception experiments. Logan & Pruitt (1995) also stated that discrimination tasks are not the best way for training listeners. This is because although an identification task requires an appropriate phoneme label in the training, it facilitates the development and usage of “phonetic memory codes” rather than “low-level sensory-based information.” Jamieson & Morosan (1986, 1989) also suggested that discrimination tasks, in general, may not work well with the task of training listeners to perceive novel phonetic categories because they tend to focus listeners’ attention on the low-level differences between stimuli. In other words, discrimination tasks focus listeners’ attention on the differences between stimuli rather than inducing changes in phonetic categorization (Logan & Pruitt, 1995: 357).

Fourth, a subject-controlled stimulus should be used in speech perception training rather than an experimenter-controlled stimulus, this is because a subject-controlled stimulus provides listeners an opportunity to have an increased number of presentations of the phones in more difficult environments. A subject-controlled stimulus is a presentation in which a listener has control over the timing of events and the selection of stimuli, while an experimenter-controlled stimulus is when both the timing of events and the selection of stimuli are controlled by the experimenter. A subject-controlled stimulus helps listeners compare between the novel stimuli and other stimuli, and it also allows them to choose to hear multiple tokens by several talkers. It optimizes training for individual differences and improves motivation to carefully listen. However, there are some disadvantages for the subject-controlled stimulus. For instance, the formulation of general principles about training based on such potentially variable training regimes may be more difficult than when experimenter-controlled presentation is chosen. It also remains to be seen whether subjects make optimal choices when selecting stimuli (Logan & Pruitt, 1995). Although there are some disadvantages about the subject-controlled stimulus, the significant advantages it brings cannot be ignored.

As an example, Wang & Munro (2004) conducted a computer-based training system for training three English vowel contrasts (i.e., /i-ɪ/, /u-ʊ/, /ɛ-æ/) to advanced ESL speakers. They stated that their study applied training techniques from previous work in a pedagogical oriented approach in which participants had some control over lesson content and worked at a self-determined pace, which is similar to the “subject-controlled stimulus presentation” mentioned here. Their training stimuli consisted of synthetic and natural utterances and the stimuli were presented in a graded fashion (the fading approach). The results showed that trainees’ perceptual performance improved, their knowledge was transferred to new contexts, and their improvement maintained three months after training.

Fifth, feedback is a crucial factor in speech perception training, because it enables subjects to determine whether what they are doing is appropriate or not. There are two types of feedback: short-term feedback (e.g., a trial-by-trial basis) and long-term feedback (e.g., a block by block feedback and a session by session feedback). The short-term feedback works better than the long-term feedback, although the required time and technology makes it more difficult to manipulate. That is because with the short-term feedback listeners can utilize the information in the feedback immediately to his or her best advantage. The long-term feedback is motivational, but sometimes confusing and it proved to be less effective in learning. There are two sub-types of the short-term feedback: correct/incorrect feedback and error feedback. The former has been more frequently used, however the latter not only helps listeners realize that they made errors, but also helps them associate the error they made with its correct category label. Flege (1987) reported that after Chinese learners received training with a small amount of feedback, their sensitivity to the word-final English /t/-/d/ contrast increased but not significantly, except for two Chinese learners whose improvement was significant.

Sixth, long-term training has been suggested to be more effective than short-term training in some aspects such as obtaining of a longer lasting effect from the training, although some short-term training was also able to improve listeners' perception on some specific features (e.g., the 10-minute period of exposure to the prevoiced region of the VOT continuum enabled American listeners to distinguish perceptually three voicing categories (Pisoni et al., 1982)). Long-term training is conducted over several days or several weeks. It can be measured by number of sessions or number of days, it ranges from 6 sessions to 45 sessions. A typical length is approximately 15 training sessions spread over three weeks (Lively et al., 1993; Logan et al., 1991; Strange & Dittmann, 1984). The length of each training session can vary from 10 minutes to 90 minutes (Pisoni et al., 1982; Nishi & Kewley-Port, 2007). Many studies showed that listeners’ performance improved most during the first 10 training sessions (Logan et al., 1991; Lively et al., 1993; Yamada, 1993). The following table presents the summary of factors for effective speech perception trainings (Logan & Pruitt, 1995).

Factors Enhancing Effective Speech Perception Trainings (Logan & Pruitt, 1995)	
1. Training methods	- Intensive laboratory training
2. Stimulus used in training	- Natural speech rather than synthetic speech - Several phonological environments rather than a single phonological environment - Multiple talkers rather than a single talker
3. Stimulus presentation	- Identification task rather than other tasks (e.g., discrimination task, category change task, etc.)
4. Stimulus control presentation	- Subject-controlled stimulus presentation rather than experimenter-controlled stimulus presentation
5. Feedback	- Immediate feedback - Correct/ Incorrect feedback - Error feedback
6. Duration of training	- Long-term training rather than short-term training

Table 2-1: Factors for Effective Speech Perception Trainings

Furthermore, Logan & Pruitt (1995) suggested two other important elements which should be included into speech perception trainings: evaluation of trainings and a control group. Firstly, pretest-posttest design is a common way to evaluate the improvement or the generalization of the listeners after going through training. The choice of stimuli in the evaluation is very important. If the generalization is to be tested the pretest-posttest stimuli should be dissimilar to the stimuli in training if learning is to be accurately tested. Typically, there are two groups in the pretest-posttest design: a control group and an experimental group. When using pretest-posttest design, both groups should not differ significantly at pretest, and the control group should show no significant change, while the experimental group subjects should show a significant improvement from pretest to posttest.

Secondly, control groups ensure that the improvements in performance between pretest and posttest were from the training and not from the exposure of listeners to the pretest-posttest stimuli or any extra experimental factors. Apart from comparing the differences between an experimental (trained) group and a control (untrained) group, the comparison of two different groups on the same training can be done. The inclusion of subjects from more than one linguistic group enables a more accurate determination of the source of similarities and differences between groups than when they are tested in separate experiments using different methodologies.

Logan & Pruitt (1995) also pointed out indicators for effective speech perception training, such as the generalization to novel words, new talkers, new tasks, or new contexts. To illustrate, the effectiveness of the training can be supported when generalization occurs. There are many types of generalization such as the transfer to new tasks, to the production of novel talkers, to new productions from the same talker(s) used in training, to new contexts, (e.g., to stimuli in which the contrasting phones occur in phonetic environments not presented in training), or to stimuli containing novel phonetic categories that share acoustic/phonetic features with the training stimuli (e.g., a voicing contrast at one place of articulation to the same voicing contrast at another place of articulation) (Lively et al., 1993; Wang & Munro, 2004). The following table presents the summary of important elements to evaluate and an indicator for effective speech perception trainings (Logan & Pruitt, 1995).

The Evaluation for Effective Speech Perception Trainings Logan & Pruitt (1995)	
1. Evaluation of training	- Pretest and posttest design should be implemented
2. Control group	- Control group should be included in the experiment
An Indicator for Effective Speech Perception Trainings Logan & Pruitt (1995)	
1. The generalization	- The generalization to novel words, new talkers, new tasks, or new contexts should occur (Lively et al., 1993; Wang & Munro, 2004)

Table 2-2: Elements for the Evaluation of Effective Speech Trainings and an Indicator for Effective Speech Trainings

Last but not least, there are other important issues found in the previous literature that need to be considered to ensure effective speech perception training: learners' language proficiency, different degree of difficulty in acquiring different segments, training segments in different phonological contexts, and L1 influence. The first example is from Polka's (1991) perception training, which trained the Hindi dental versus retroflex stops in different voicing contexts (i.e., breathy voiced, prevoiced, and voiceless aspirated) for English listeners, showed that only rapid learners and a near-native performer could generalize the training to perception of the contrast in one of the two novel contexts. In line with Polka's (1991) results, Lerdpaisalwong & Park (2013) and the results of the pretest of the current study revealed that Thai EFLs with English language proficiency ranging from low-intermediate to low had difficulty perceiving the six coda stops (i.e., /b d g p t k/), while that was not the case for Thai EFLs moderate and high English language proficiency. This means that when conducting a perception study or perception training, learners' learning rates and proficiency levels should be taken into consideration.

Another example is from Polka (1991) revealing that training with both breathy voiced and voiceless unaspirated stops could improve the perception of the contrast in the breathy voiced context and also in the (novel) voiceless aspirated context, but not in (the most difficult) prevoiced context. Corresponding with Polka (1991), the results from the pretest of the current study revealed that Thai EFLs with low-intermediate English proficiency had less difficulty perceiving the onsets /p t k/ than the codas /p t k/. This fact emphasizes that segments being tested or trained can vary in degree of difficulty. This, therefore, needs to be taken into consideration as well.

The third example is from Rochet's (1995) training showing that the Chinese subjects who were native speakers of a language that permits obstruents in word-final position seemed to benefit more from the training than those whose native language (L1) has no word-final obstruents. This was interpreted to mean that syllable-processing strategies established during L1 acquisition may influence later L2 learning. Therefore, when conducting a perception study or perception training, learners' L1 needs to be taken into consideration (e.g., the control of learners' L1), since it can influence their L2 performance and learning.

The last example is from Rochet's (1995) study in which subjects did not generalize the trained phonemes to different word positions, for example, syllable-final or intervocalic positions of /b/ and /p/. This signifies that L2 learners need to be trained with words containing target contrasts in as many word positions as possible (Rochet, 1995; Lively et al., 1993).

In conclusion, this section presents the six factors proved to be useful for training speech perception. The elements for evaluating speech perception training are suggested (i.e., the pretest and the posttest and a control group), as well as an indicator for effective speech perception trainings (e.g., the generalization to new talkers). Also, other issues that need to be considered and can affect the trainings are introduced. Those issues are learners' language proficiency, different degree of difficulty in acquiring different segments, training segments in different phonological contexts, and L1 influence.

3. Description of Consonant and Vowel Inventory
3.1 Description of English and Thai Consonant Inventory

This section presents fundamental features of English and Thai consonants. English has 24 consonants that can be classified in terms of place of articulation, manner of articulation, and voicing. Thai has 21 consonants (See Table 2-3). Much of the lexicon is monosyllabic, however polysyllabic words do exist though most of them are loanwords, especially from the Khmer and classical Indian languages Sanskrit and Pali (Panlay, 1997: 17).

Table 2-3 presents both English and Thai consonant inventories in order to provide clear comparison between the two. By doing so, it is easy to see the differences and similarities between the two systems (i.e., English and Thai). The top row presents places of articulation, starting from the most forward articulation (bilabial) and moving toward those sounds made in the back of the mouth (velar) and in the throat (glottal). The far-left column presents manners of articulation. By convention, the voiced-voiceless distinction is shown by putting the voiceless symbols to the left of the voiced symbols.

Manner of Articulation \ Place of Articulation		Bilabial	Labiodental	Dental	Alveolar	Post alveolar	Palatal	Velar	Glottal
Stop	English	p b			t d			k g	
	Thai	p b p^h			t d t^h		c c^h	k k^h	ʔ
Nasal	English	m			n			ŋ	
	Thai	m			n			ŋ	
Fricative	English		f v	Θ ð	s z	ʃ ʒ			h
	Thai		f		s				h
Affricate	English					tʃ dʒ			
	Thai								

Liquid	English				l ɹ				
	Thai				l r				
Glide	English	(w)					j	w	
	Thai	w					j	(w)	

Table 2-3: English and Thai Consonants (adapted from Bickner & Hudak, 1990, Kasuriya, Jitsuhiro, Kikui, & Sagisaka, 2002, Ladefoged & Johnson, 2011, Panlay, 1997, and Roengpitya, 2001)

There are two other points need to be made here. First, English affricates /tʃ/ and /dʒ/ are presented in Table 2-3 in order to illustrate a clear picture of English consonant inventory and its comparison to that of Thai. Ladefoged & Johnson (2011) explain that the reason why English affricates /tʃ/ and /dʒ/ are usually not listed separate in the table is because, although they are contrastive sounds in English, there is the problem of deciding whether to put them in the palato-alveolar column (the place of the fricative element) or in the alveolar column (the place of the stop element). Second, English /w/ are presented in two places in Table 2-3 (i.e., bilabial and velar). Ladefoged & Johnson (2011) explained that this is because it is articulated with both a narrowing of the lip aperture, which makes it bilabial, and a raising of the back of the tongue toward the soft palate, which makes it velar.

3.1.1 English Consonants

3.1.1.1 English Stops

English has three voiceless stop phonemes /p t k/ and three voiced stop phonemes /b d g/. The voiceless stops /p t k/ are aspirated in syllable-initial position preceding stressed vowels (e.g., *pin*, *team*, *kick*, and *apart*), however they are unaspirated after syllable-initial /s/ (e.g., *spy*, *style*, and *sky*). Each of the English voiceless stops /p t k/ has three allophones (i.e., aspirated released [p^h t^h k^h], unaspirated released [p t k], and unaspirated unreleased [p̚ t̚ k̚]). The amount of voicing of the three voiced stops /b d g/ in English depends on the context in which it occurs. When they occur in the middle of a word or phrase where they are between voiced sounds (e.g., *a buy* and *a dye*), voicing generally occur throughout the stop closure. However, when they occur in sentence initial position or after a voiceless sound (e.g., *that boy*), there tends to be no voicing during the closure of the voiced stops (Ladefoged & Johnson, 2011). They occur in both initial and final positions (e.g., *bit*, *dad*, *gap*, *mob*, *bed*, and *leg*). The glottal stop sometimes occurs at the beginning of English words that start with a vowel in the spelling (e.g., *eek*, *oak*, *ark*, etc.). It can occur in *uh-oh* /ʔʌʔoʊ/ and it can be sometimes alternate as an allophone of /t/ in words like *kitten* and *Batman*.

Acoustically, the movements of the second and third formants are the characteristics used to distinguish different stop consonants. The movements of the first formant mark the stop closure of stop consonants, as the frequency of the first formant increases when they are at the beginning of a syllable and falls when they are at the end. The movements of the second and the third formants distinguish these stops from one another. For instance, the F2 is lower for /b/ than that for /d/, which is lower than that for /g/ (See Figure 2-1). English has another set of stop consonants (i.e., /p t k/) and the movements of the formants of this set is similar to those of the sounds /b d g/ (Ladefoged, 2005).

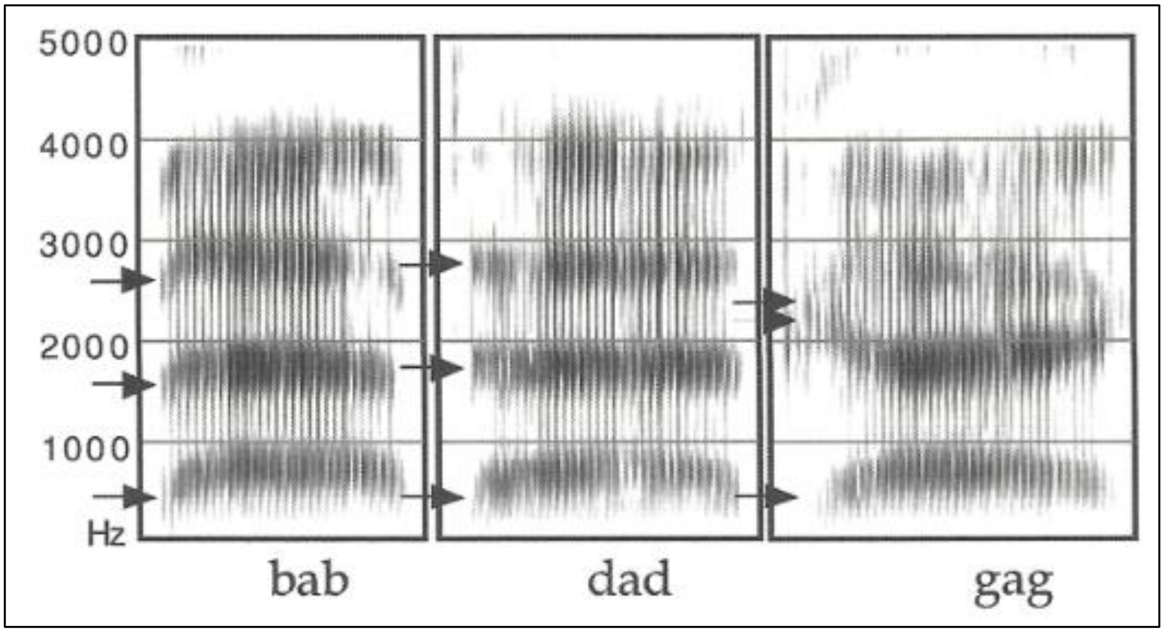


Figure 2-1: Spectrograms of Stops in *bab*, *dad*, *gag*. The Arrows Mark the Origins of the First Three Formants (Ladefoged, 2005).

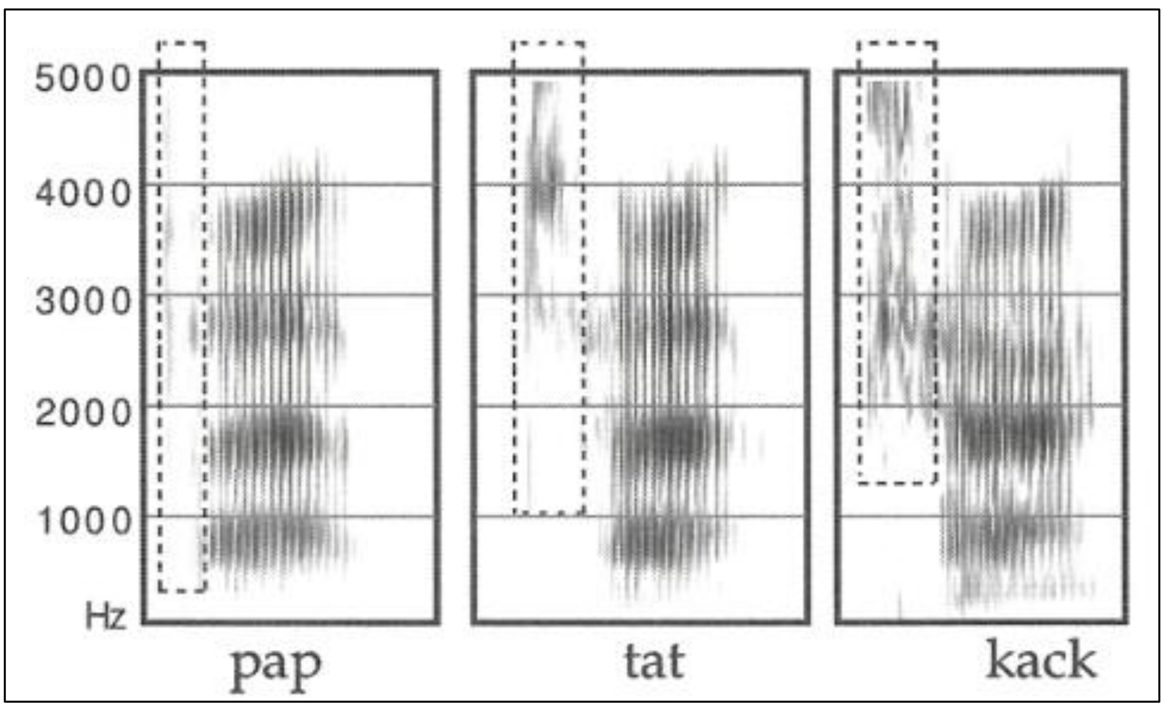


Figure 2-2: Spectrograms of Stops in *pap*, *tat*, *kack* (as in *cackle*) (Ladefoged, 2005).

3.1.1.2 English Fricatives and Affricates

English has five voiceless fricatives phonemes /f θ s ʃ h/ and four voiced fricative phonemes /v ð z ʒ/. All five voiceless fricatives occur in initial position (e.g., *fin*, *thin*, *sick*, *shape*, and *head*), however only four voiceless fricatives (i.e., /f θ s ʃ/) can occur in final position (e.g., *beef*, *bath*, *boss*, and *fish*). The three voiced fricative phonemes (i.e., /v ð z/) occur both in initial position (e.g., *van*, *than*, and *zip*) and in final position (e.g., *cave*, *breathe*, and *jazz*) while /ʒ/ occurs in initial position in loanwords (e.g., *genre*), in medial position (e.g., *leisure* and *treasure*) and in final position (e.g., *garage* and *mirage*). English has one voiceless affricate phoneme /tʃ/ and one voiced affricate phoneme /dʒ/, both of which can occur in initial and final positions (e.g., *cheap*, *jam*, *touch*, and *page*).

Acoustically, the spectrogram of /f/ as in *fie* on the left of Figure 2-3 shows that the noise spreads over a wide range of frequencies and there is a region in which there is greater intensity: 3,000 and 4,000 Hertz (Hz). The spectrogram of /θ/ also shows energy over a range of requencies, but in the higher frequency range: 8,000 Hz. There are diffrences between the formants of the adjacent vowels of /f/ and /θ/. The fourth formant is below 4,000 Hz in *fie* and above it in *thigh*. The second formant in *fie* also starts at a little bit lower frequency (i.e., around 1,200 Hz) and moves upwards, while the second formant in *thigh* starts at around 1,250 Hz.

The fricative /s/ as in *sigh* has a large amount of energy in the upper part of the figure, which is above 10,000 Hz, and has little energy below 3,500 Hz, as well as a noticeable intense band above 5,000 Hz. The sound /ʃ/ has more energy at a slightly lower frequency, centered at a little above 3,000 Hz (See Figure 2-3) (Ladefoged, 2005).

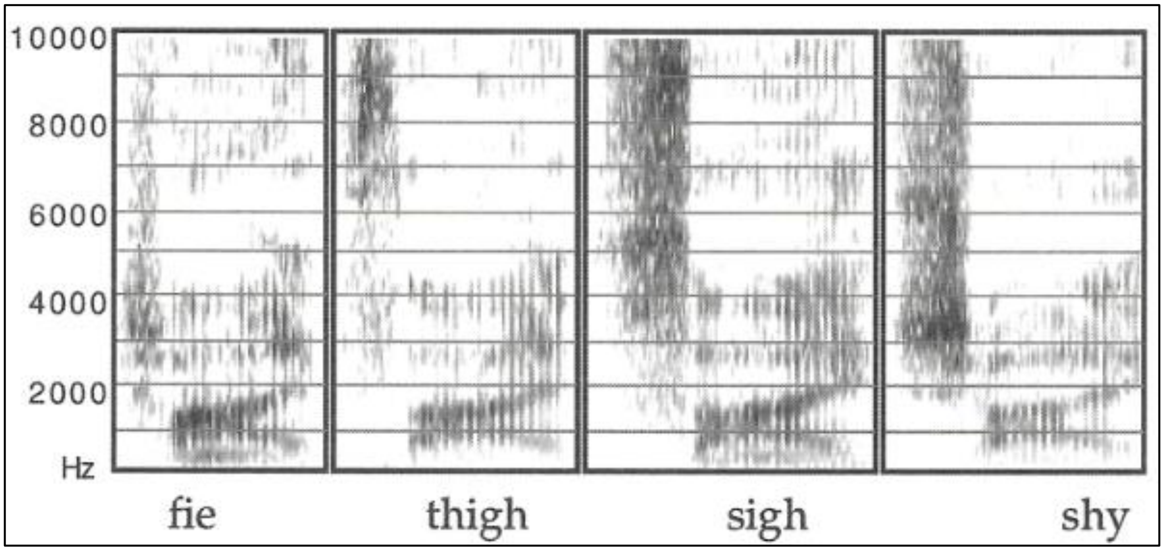


Figure 2-3: Spectrograms of Voiceless Fricatives in *fie*, *thigh*, *sigh*, *shy* (Ladefoged, 2005).

The spectrogram of /h/ in *high* shows that there is a noisy third formant at a little below 3,000 Hz, and there are faint traces of the first two formants (See Figure 2-4) (Ladefoged, 2005).

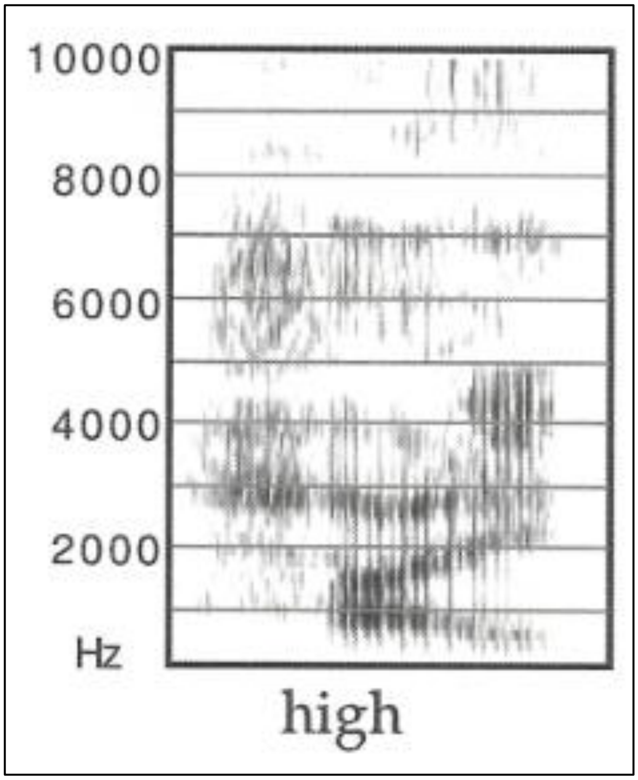


Figure 2-4: Spectrograms of /h/ in *high* (Ladefoged, 2005).

The spectrograms of /v/, /ð/, and /z/ show very faint formants during the initial fricatives of these three words *vie*, *thy*, and *Zion*. There is only a little random energy in the higher frequencies of the words *vie* and *thy*. But the effects of the turbulent airstream produced by the friction in the word *Zion* are clearly visible (See Figure 2-5) (Ladefoged, 2005).

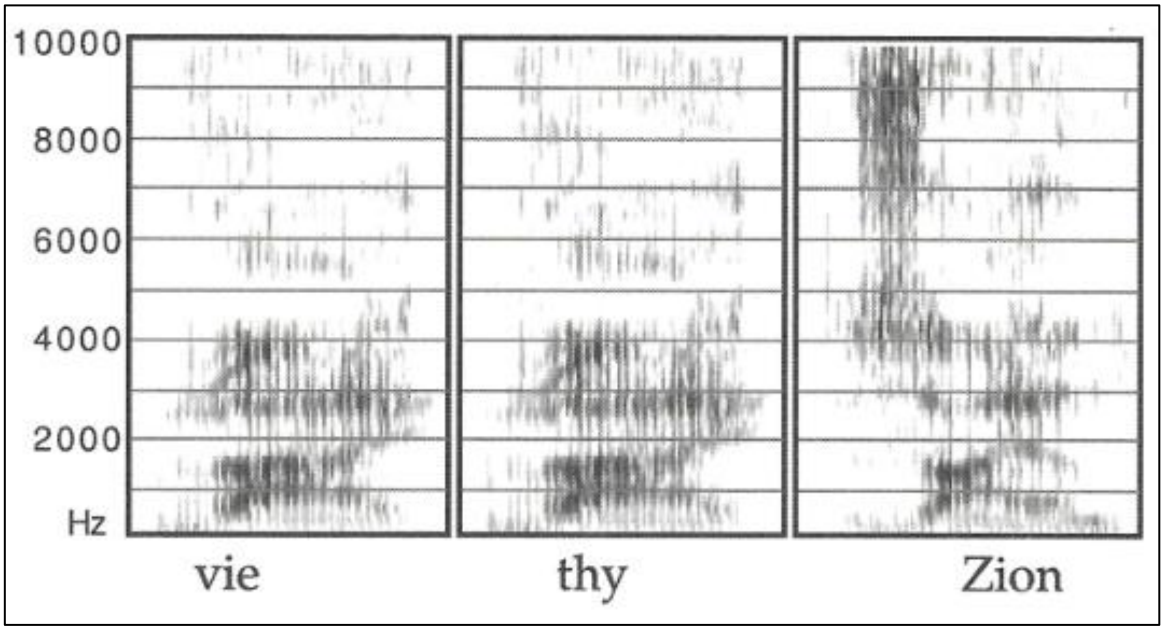


Figure 2-5: Spectrograms of the Voiced Fricatives in *vie*, *thy*, *Zion* (Ladefoged, 2005).

Figure 2-6 shows the differences between the voiced and voiceless fricatives /ʒ/ and /ʃ/. The fricatives in the middle of each word are indicated by the placement of the phonetic symbols. Under the /ʒ/ in the first word (the area between the dashed lines), there are vertical striations associated with vibrations of the vocal folds. And these indications of the vocal fold vibrations are difficult to see. Therefore, the lines at the top of the figure make them a little clearer. Under /ʃ/ there is only the noise due to the turbulent airstream.

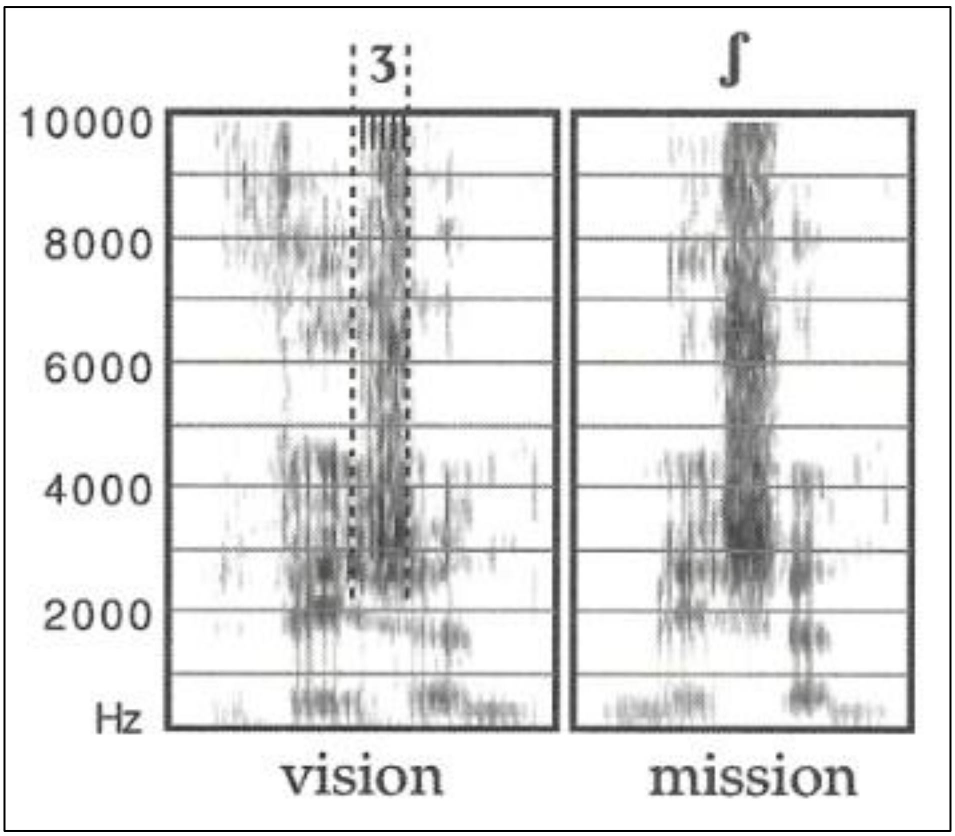


Figure 2-6: Spectrograms Showing the Contrast between the Voiced Fricative in *vision* and the Voiceless Fricative in *mission* (Ladefoged, 2005).

Figure 2-7 presents the sound /tʃ/ in *chime*. And the sound /dʒ/ in *jive*, which is the combination of /d/ and /ʒ/. In Figure 2-7, it is difficult to see the initial /t/ in *chime*, except the abrupt beginning of the following /ʃ/. The vertical striations due to the vibrations of the vocal folds are just visible in /ʒ/ in *jive*. Both the voiceless /ʃ/ and the voiced /ʒ/ are considered shorter than when they occur on their own (See Figure 2-7) (Ladefoged, 2005).

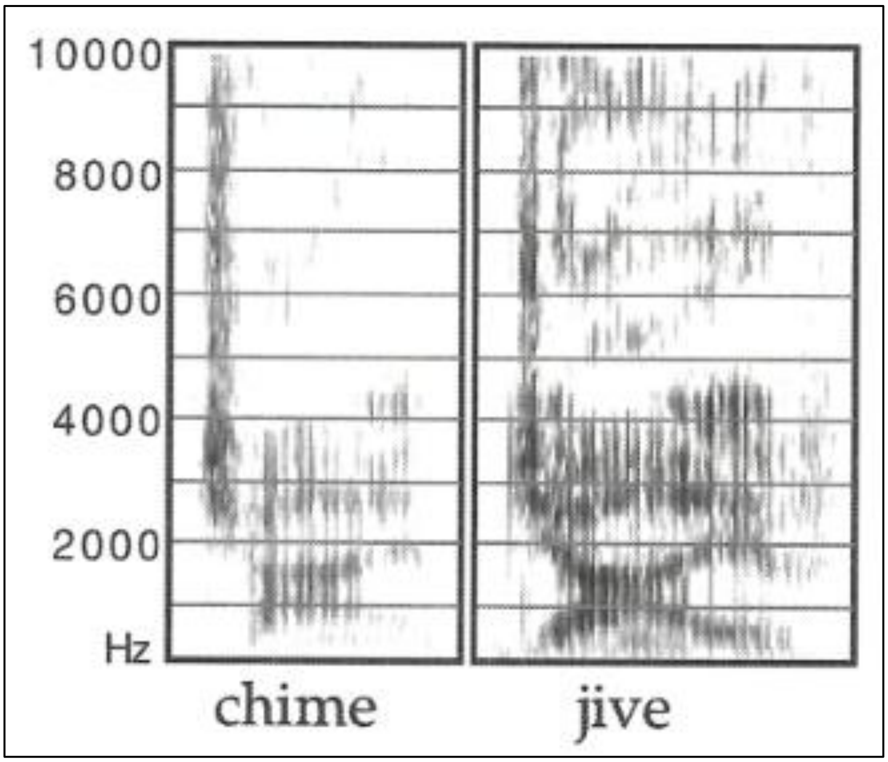


Figure 2-7: Spectrograms Showing the Contrast between the Voiceless Affricate in *chime* and the Voiced Affricate in *jive* (Ladefoged, 2005).

3.1.1.3 English Nasals

English has three nasal phonemes (i.e., /m n ŋ/). /m/ and /n/ occur in both initial and final positions (e.g., *my*, *night*, *ram* and *ran*). /ŋ/ occurs word medially between vowels (e.g., *singing* and *singer)* and before the voiceless and voiced velar stops /k g/ (e.g., *anchor* and *anger*). It also occurs before final /k/ (e.g., *link* and *thank*), however it cannot occur in initial position.

Figure 2-8 illustrates that there is a sharp discontinuity (marked by an arrow) when the lips come together or the tongue comes up to contact the roof of the mouth to allow the air to come out through the nose. After this point, there is less amplitude in the nasal consonant itself. All three nasals have a first formant, which has clearly less energy than its preceding vowel, and a very low frequency around 200 Hz. Each of them has a visible formant in the nerighborhood of 2,500 Hz, but very little energy in the region normally occupied by the second formant. And this is a typical pattern found in the nasal consonants (Ladefoged, 2005).

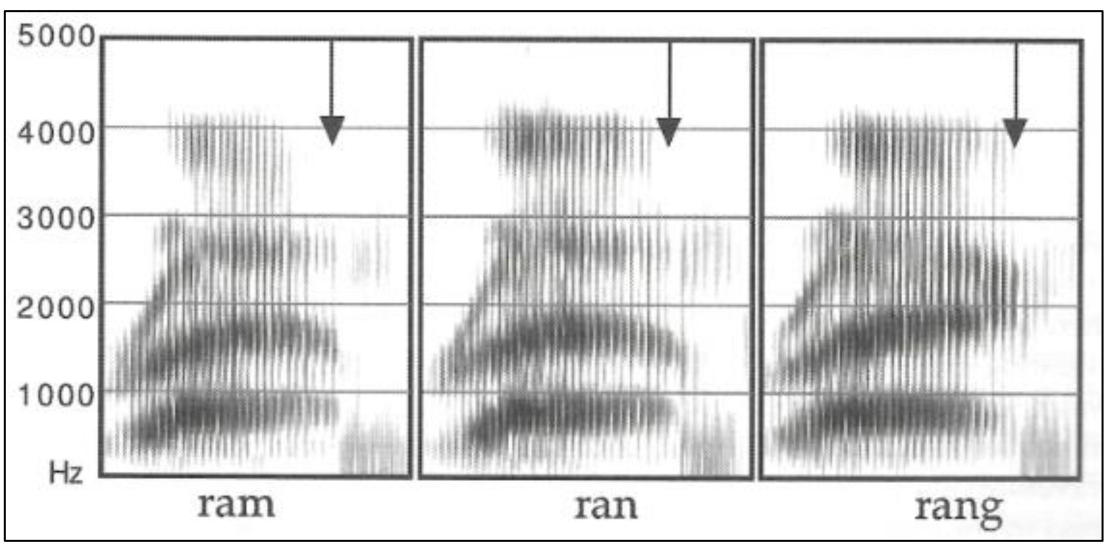


Figure 2-8: Spectrograms of Nasals at the Ends of the Words *ram*, *ran*, *rang*. The arrows mark the onsets of the nasal (Ladefoged, 2005).

3.1.1.4 English Approximants

English has four approximants: /ɹ/, /l/, /w/, and /j/. /ɹ/ and /l/ occur in both initial and final positions (e.g., *lead*, *read*, *feel* and *care*). The articulations of these sounds vary depending on the articulation of the following vowel. Most forms of American English /l/ are velarized, except the ones that are syllable initial and between high front vowels, such as *freely*. /w/ and /j/ occur in initial position (e.g., *wine* and *young*). The approximants /ɹ w l/ can occur in consonant clusters with stop consonants (e.g., *pray*, *twin*, and *dwell*). They are partially voiceless when they follow one of the voiceless stops /p t k/ (e.g., *play* [pl̥eɪ], *twice* [tw̥aɪ], and *clay* [kl̥eɪ]). The approximant /j/ can occur in similar consonant clusters, such as *pew* [pj̥u] and *cue* [kj̥u]. The tongue is in a different position when pronouncing the same segment following by a different vowel, such as *we*, *water*, *reap*, *raw*, *lee*, *law*, *ye*, and *yaw* (Ladefoged & Johnson, 2011).

Acoustically, the obvious aspect of the /w/ in *wet* is the rising second formant. The first formant also goes up but less than the second formant. And the third formant has much the same frequency at the beginning and end of the word. The /j/ in *yet* has a falling second formant and more rise of the first formant, and a drop of the third formant. The /l/ in *let* is different from the first two sounds in that before the moment indicated by the arrow, there is a faint formant at a very low frequency and antoher faint bar at about 1,500 Hz. Right after the arrow, the formants have a much higher intensity as we can see the darker bars and are at a dinstinctly different frequency. The same kind of changes can be observed in the higher frequencies above 3,000 Hz. These changes occur because of the abrupt change in the articulation, which is the tip of the tongue is in contact with the roof of the mouth for the /l/, and then breaks away from it for the vowel (Ladefoged, 2005). The /ɹ/ at the beginning of *retch* has the very low frequency of the third formant. All the formants rise at the beginning of this word, but the movement of the third formant is the most significant. Whenever there is an /ɹ/ in a word the third formant will be below 2,000 Hz as indicated by the arrow in Figure 2-9 (Ladefoged, 2005).

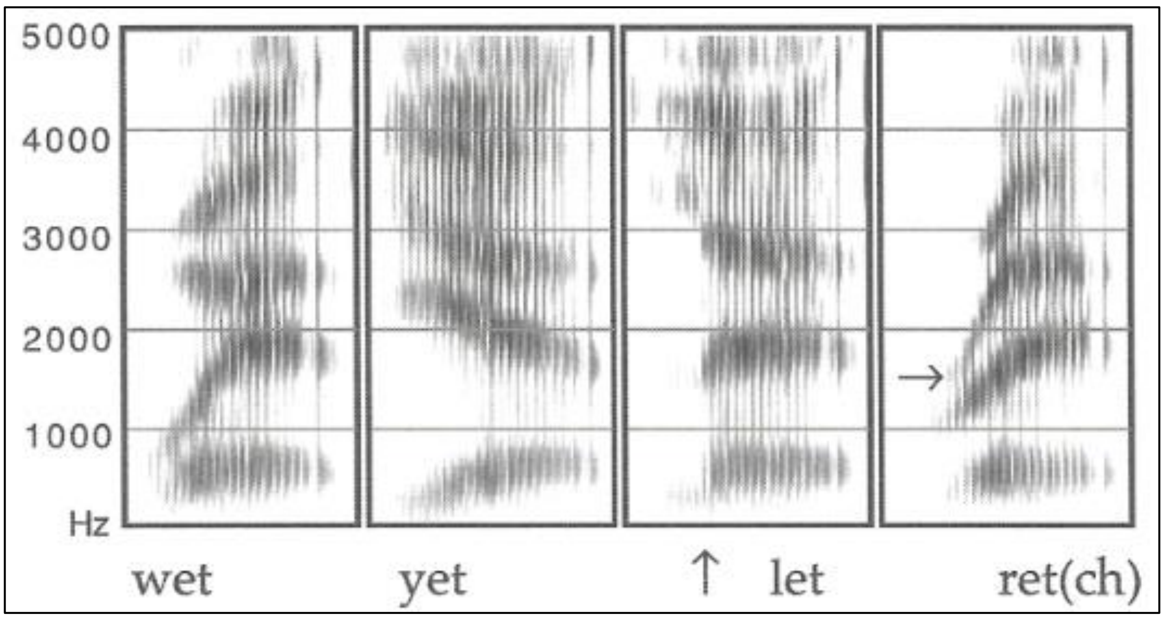


Figure 2-9: Spectrograms of Approximants in *wet*, *yet*, *let*, *recth* (Ladefoged, 2005).

Figure 2-9 shows that the arrow below the third spectrogram marks the moment when the tip of the tongue, which is raised for /l/, comes away from the roof of the mouth. The arrow in the fourth spectrogram shows the low beginning of the third formant (Ladefoged, 2005).

In sum, when considering onset and coda consonants, among 24 English consonants presented in Table 2-3, 22 consonants can be in word-initial position (i.e., onsets). Those phonemes are /p b t d k g m n f v θ ð s z ʃ h tʃ dʒ l w ɹ j/. And 21 consonants can be in word-final position (i.e., codas). Those phonemes are /p b t d k g m n ŋ f v θ ð s z ʃ ʒ tʃ dʒ l w ɹ j/ (See Table 2-4).

English Consonants		
Manner of Articulation	**22 Onsets**	**21 Codas**
Voiceless stops	/p/ *p*ie /t/ *t*ie /k/ *k*ye	/p/ la*p* /t/ fi*t* /k/ ne*ck*
Voiced stops	/b/ *b*y /d/ *d*ye /g/ *g*uy	/b/ mo*b* /d/ be*d* /g/ do*g*
Nasals	/m/ *m*y /n/ *n*ight	/m/ ra*m* /n/ ra*n* /ŋ/ ra*ng*
Fricatives	/f/ *f*ie /v/ *v*ie /θ/ *th*igh /ð/ *th*y /s/ *s*igh /z/ *Z* /ʃ/ *sh*y /h/ *h*igh	/f/ bee*f* /v/ ca*ve* /θ/ ba*th* /ð/ brea*the* /s/ bo*ss* /z/ ja*zz* /ʃ/ fi*sh* /ʒ/ gara*ge*
Affricates	/tʃ/ *ch*i(me) /dʒ/ *j*i(ve)	/tʃ/ tou*ch* /dʒ/ pa*ge*
Approximants	/l/ *l*ie /ɹ/ *r*ye /w/ *w*hy /j/ *y*ou	/l/ fee*l* /ɹ/ ca*r*

Table 2-4: English Onsets and Codas (adapted from Ladefoged & Johnson, 2011)

3.1.2 Thai Consonants

3.1.2.1 Thai Stops

Thai has four voiceless aspirated stop phonemes /p^h t^h k^h c^h/ (e.g., /p^hai/ ‘danger’, /t^hi:/ ‘time’, /c^ha:m/ ‘bowl’, and /k^ha:/ ‘stuck’) and four voiceless unaspirated stop phonemes /p t k c/ (e.g., /paj/ ‘go’, /ti:/ ‘hit’, /ka:/ ‘crow’, and /ca:n/ ‘dish’). Thai also has one glottal stop (e.g., /ʔa:n/ ‘read’). All of these voiceless stops occur in initial position, however only three voiceless unreleased (i.e., /p t k/) and a glottal stop is permitted in final position (e.g., /kap/ ‘with’, /cet/ ‘seven’, /p^hak/ ‘rest’, and /caʔ/ ‘will’). Thai has two voiced stops /b d/ which only occur in initial position (e.g., /ba:p/ ‘sinful’ and /dæ:ŋ/ ‘red’).

3.1.2.2 Thai Fricatives and Affricates

Thai has three voiceless fricative phonemes /f s h/, which are permitted only in initial position (e.g., /fa:/ ‘sky’, /si:/ ‘color’, and /ha:/ ‘five’). Thai has two affricates /c^h c/, which are also permitted only in initial position (e.g., /c^ha:m/ ‘bowl’ and /ca:n/ ‘dish’).

3.1.2.3 Thai Nasals

Thai has three nasal phonemes (i.e., /m n ŋ/), which occur both in initial and final positions (e.g., /mɯ:/ ‘hand’, /nap/ ‘to count’, /ŋən/ ‘money’, /lɯ:m/ ‘to forget’, /pɯ:n/ ‘gun’, and /daŋ/ ‘loud’).

3.1.2.4 Thai Liquids

Thai has two liquid phonemes. One is a trill /r/ and the other one is a lateral /l/. Both phonemes occur only word-initial position (e.g., /rɯ:a/ ‘boat’ and /liŋ/ ‘monkey’) (Panlay, 1995; Rungruang, 2007).

3.1.2.5 Thai Approximants

Thai has two approximants /w j/, which occur both in initial and final positions (e.g., /wan/ ‘day’, /jon/ ‘admire’, /jaw/ ‘long’, and /kaj/ ‘chicken’).

3.1.2.6 Thai Final Consonants

Only nine Thai consonants (i.e., /p t k ʔ m n ŋ w j/) can occur in word-final position (e.g., /kap/ ‘with’, /wa:t/ ‘to draw’, /rak/ ‘to love’, /caʔ/ ‘will’, /ha:m/ ‘to carry’, /wan/ ‘day’, /daŋ/ ‘loud’, /ja:w/ ‘long’, and /k^ha:j/ ‘to sell’).

In sum, when considering onset and coda consonants, among 21 Thai phonemes presented in Table 2-3, all of the phonemes can be in word-initial position. Only nine phonemes can be in word-final position. Those phonemes are /k t p ʔ ŋ n m j w/ (See Table 2-5).

Thai Consonants		
Manner of Articulation	**21 Onsets**	**9 Codas**
Aspirated voiceless stops + Affricates	/p^h/ (พ, ผ, ภ) /p^{h}aj/ ‘danger’ /t^h/ (ท,ธ,ฑ,ฐ,ถ,ฒ) /t^{h}i:/ ‘time’ /c^h/ (ฉ,ช,ฌ) /c^{h}a:m/ ‘bowl’ /k^h/ (ข,ฃ,ค,ฅ,ฆ) /k^{h}a:/ ‘stuck’	-
Unaspirated voiceless stops + Affticates	/p/ (ป) /paj/ ‘to go’ /t/ (ต,ฏ) /ti:/ ‘to hit’ /c/ (จ) /ca:n/ ‘dish’ /k/ (ก) /ka:/ ‘crow’ /ʔ/ (อ) /ʔa:n/ ‘to read’	/p/ (บ,ป,พ) /kap/ ‘with’ /t/ (ด,ต,ฎ,ฏ) /wa:t/ ‘to draw’ - /k/ (ก) /rak/ ‘to love’ /ʔ/ (Cvʔ) /caʔ/ ‘will’
Unaspirated Voiced stops	/b/ (บ) /ba:p/ ‘sinful’ /d/ (ด,ฎ) /dæ:ŋ/ ‘red’	-
Nasals	/m/ (ม) /mɯ:/ ‘hand’ /n/ (น,ณ) /nap/ ‘to count’ /ŋ/ (ง) /ŋən/ ‘money’	/m/ (ม) /ha:m/ ‘to carry’ /n/ (น,ญ,ณ,ร,ล,ฬ) /wan/ ‘day’ /ŋ/ (ง) /daŋ/ ‘loud’
Fricatives	/f/ (ฟ) /fa:/ ‘sky’ /s/ (ศ,ส) /si:/ ‘color’ /h/ (ห,ฮ) /ha:/ ‘five’	-
Liquids	/l/ (ล,ฬ) /lɯ:m/ ‘to forget’ /r/ (ร) /rɯ:a/ ‘boat’	-
Glides	/w/ (ว) /wan/ ‘day’ /j/ (ย,ญ) /ja:w/ ‘long’	/w/ (ว) /ja:w/ ‘long’ /j/ (ย) /k^{h}a:j/ ‘to sell’

Table 2-5: Thai Onsets and Codas (adapted from Panlay, 1997)

3.2 Description of Thai and English Vowel Inventory

Height \ Frontness		Front	Central	Back
High	English	ɪ, i	-	ʊ, u
	Thai	i, iː	ɯ, ɯː	u, uː
Mid	English	ɛ	ə, ʌ	ɔ
	Thai	e, eː	ɤ, ɤː	o, oː
Low	English	æ	-	ɑ
	Thai	æ, æː	a, aː	ɔ, ɔː[2]

Table 2-6: Thai and English Monophthongs (adapted from Ladefoged, 1993 and Roengpitya, 2001)

Table 2-6 presents both English and Thai monophthongs based on auditory description in order to provide clear comparison of both inventories. By doing so, it is easy to see the differences and the similarities between the two systems (i.e., English and Thai). One thing that needs to be noted here is that the auditory quality of each vowel is changed when the tongue moves from one vowel to another. However, because it is difficult to say exactly how the tongue moves unless X-ray or MRI is used to monitor the tongue, the simple labels (i.e., *high*/*low* and *front*/*back*) used here represent the auditory qualities of different vowels rather than the tongue positions. They represent the way one vowel sounds relative to another (Ladefoged & Johnson, 2011).

[2]Traditionally, the IPA symbols /ɔ/ and /ɔː/ are used to describe Thai low back vowel.

3.2.1 English Vowels

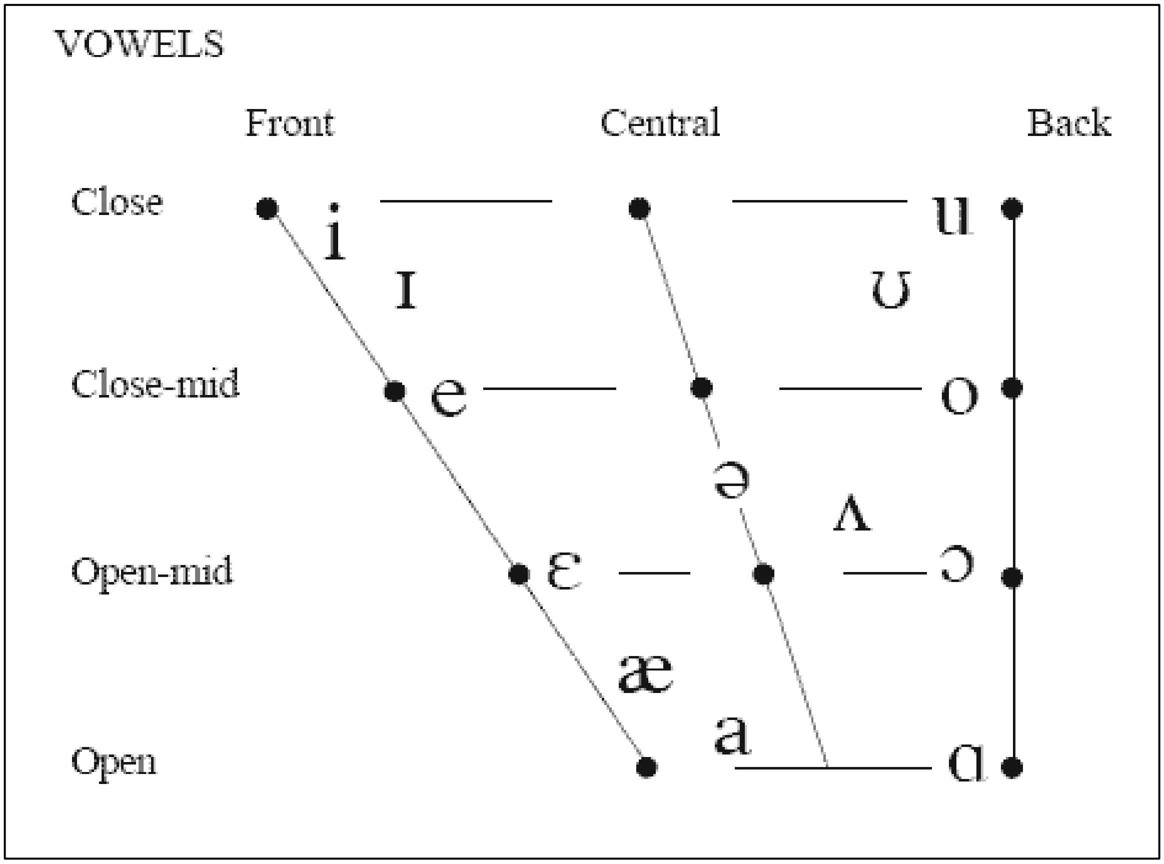


Figure 2-10: Standard American English Vowels Chart (adapted from Ladefoged & Johnson, 2011)

Figure 2-10 presents American English vowels based on auditory description. The simple labels (i.e., *high*/*low* and *front*/*back*) used here represent the auditory qualities of different vowels rather than the tongue positions. They represent the way one vowel sounds relative to another (Ladefoged & Johnson, 2011)

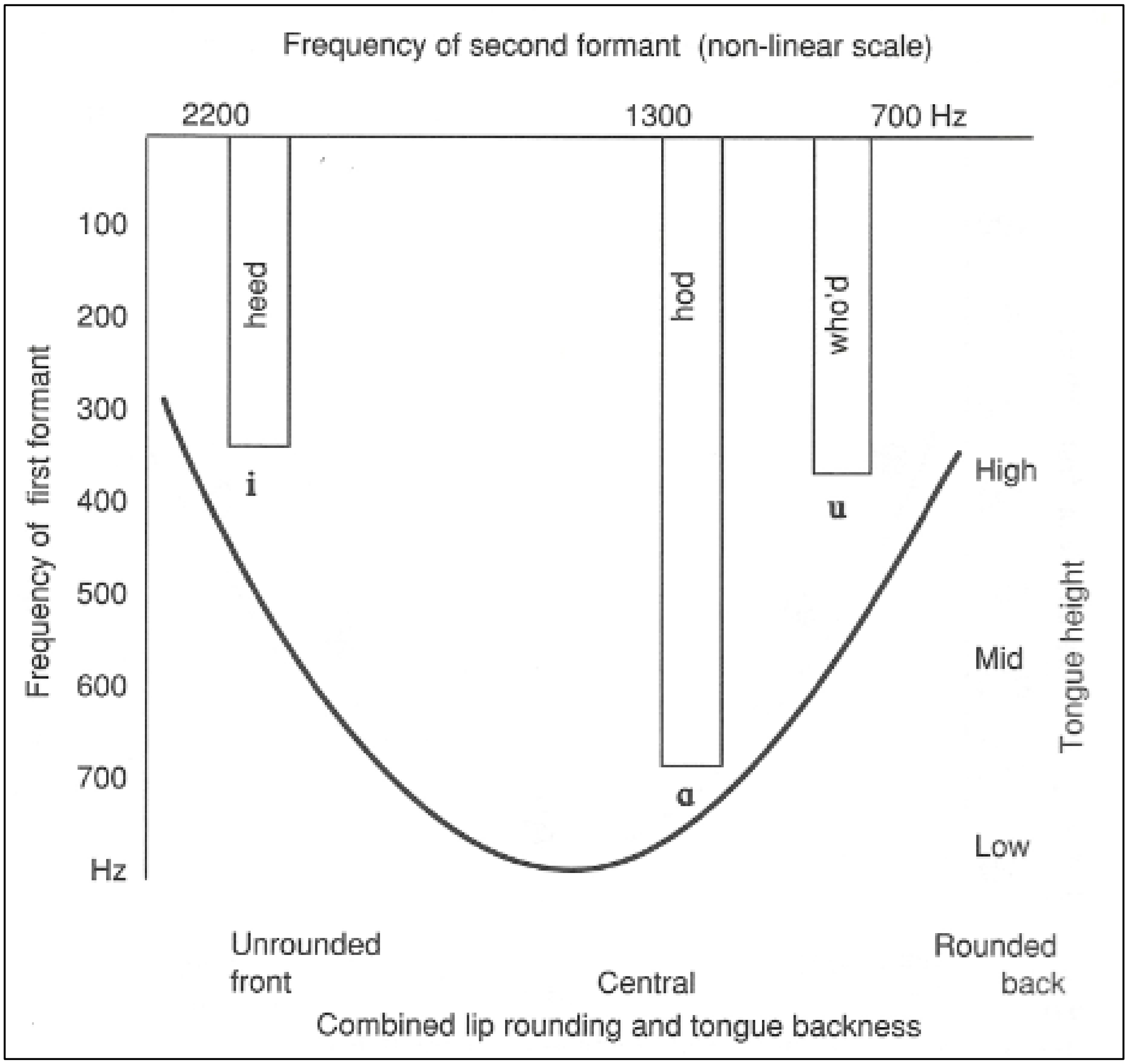


Figure 2-11: The Combined Lip Rounding and Tongue Backness Vowel Chart (Ladefoged, 2005)

Figure 2-11 presents three American English monophthongs based on the information of formants one and two. The first formant in the vertical axis relates to tongue height. The second formant in the horizontal axis relates to the front-back position of the tongue and the degree of lip rounding (Ladefoged, 2005).

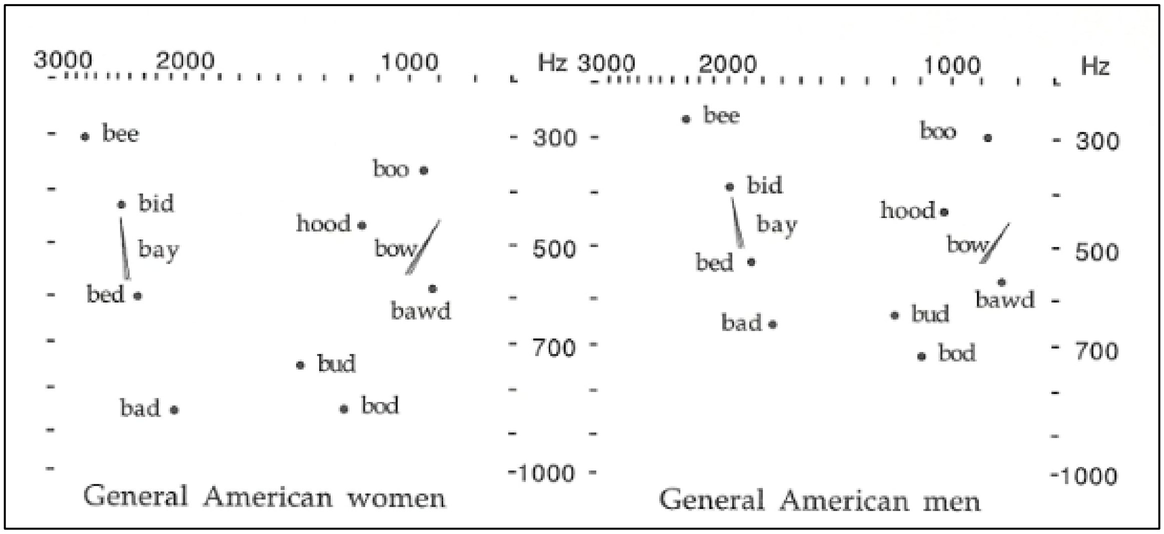


Figure 2-12: The General Amercian Women's and Men's Vowel Chart (Ladefoged, 2005)

Figure 2-12 presents the general American English vowels produced by women (left) and men (right) and recorded in the 1950s. The first formant in the middle of the figure relates to tongue height. The second formant at the top of the figure relates to the front-back position of the tongue and the degree of lip rounding (Ladefoged, 2005).

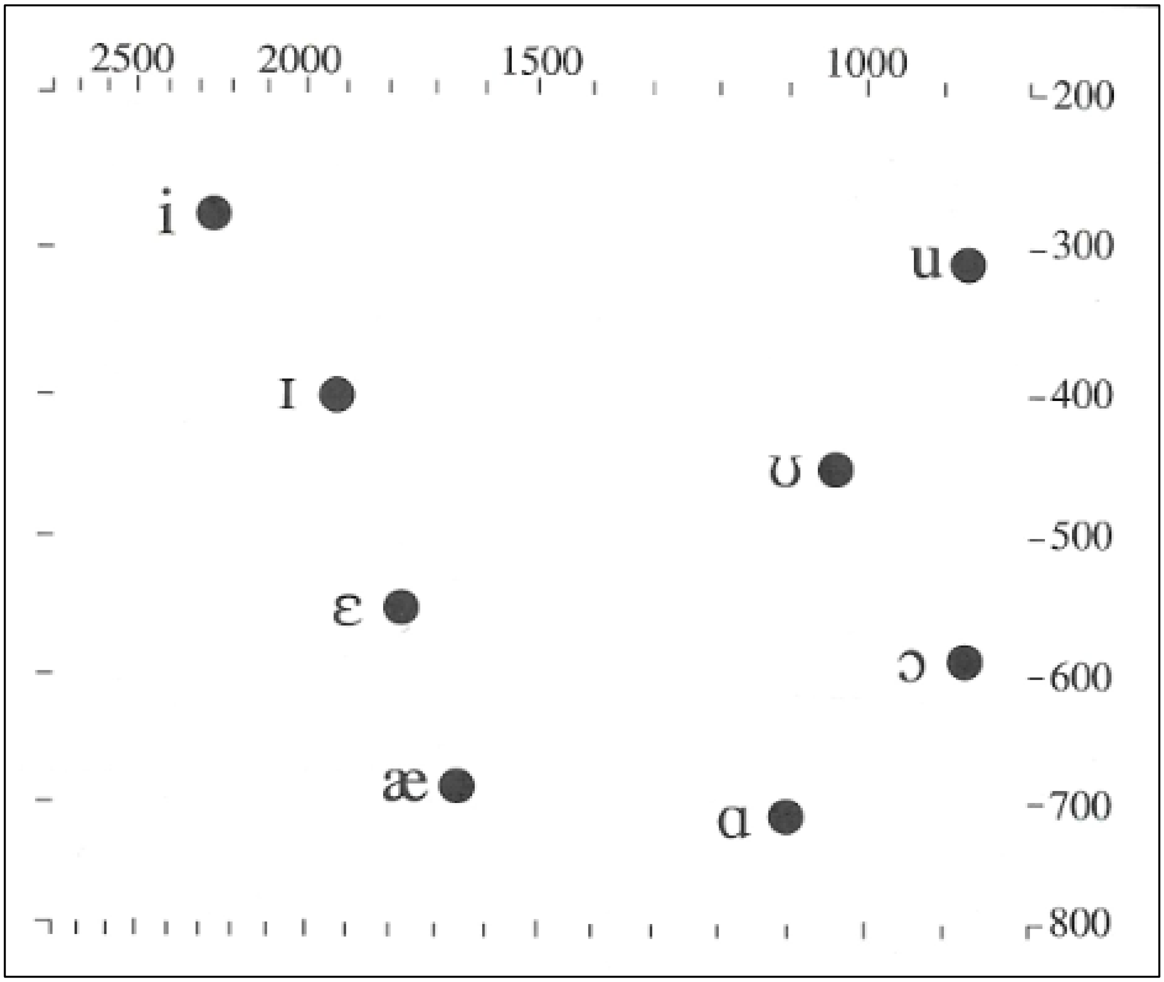


Figure 2-13: The Eight American English Vowels in Bark Scale Intervals (Ladefoged & Johson, 2011)

Figure 2-13 presents a formant chart showing the frequency of the first formant on the ordinate (the vertical axis) plotted against the second formant on the abscissa (the horizontal axis) for eight American Engish vowels. The scales are marked in Hz, arranged at Bark scale intervals (Ladefoged & Johnson, 2011).

3.2.1.1 English Monophthongs

Standard American English has four front monophthongs /i ɪ ɛ æ/ as in *deep*, *fit*, *neck*, and *cat*. The auditory distances between these four vowels are about the same. American English also has four back monophthongs /ɑ ɔ ʊ u/ as in *lot*, *dog*, *hook*, and *boot*. Unlike the four front monophthongs, the back monophthongs' auditory space is not distributed evenly. There are two English central vowels /ə ʌ/, which are allophones of each other. The vowel /ə/ occurs in unstressed syllables, whereas the vowel /ʌ/ occurs in stressed syllables, such as in *above* /əbʌv/ (See Figure 2-10 and Figure 2-12). Front, central, and low back vowels in English are generally unrounded, while non-low back vowels are generally rounded. A sequence of two syllabic vowels are possible in English, such as in '*poem*' /poᶷɛm/, '*radio*' /reᶦdio/, '*chaos*' /keᶦɑs/ (Ladefoged, 2005; Ladefoged & Johnson, 2011; Panlay, 1997).

There are a couple of points to note about Figures 2-10, 2-12, and 2-13. Firstly, Figure 2-10 and Figure 2-12 both present information on American English vowels. But, Figure 2-10 presents the information using the simple terms (i.e., *hight/low* and *front/back*), while Figure 2-12 presents the acoustic information (i.e., Formant one and two). Secondly, the dialect presented in Figure 2-12 is more old-fashioned dialect than that of most contemporary speakers, since the data was collected in 1950s. However, it can still provide appropriate acoustic information on the general American English vowels. Thirdly, there is difference between the women on the left of the figure and the men on the right. The men's vowels have lower formant frequencies, which makes the chart more compressed. Therefore, all the points (vowels) were moved upward and to the right (Ladefoged, 2005). Lastly, the frequencies in Figure 2-13 have been presented in the Bark scale, which means perceptually equal intervals of pitch are represented as equal distances along the scale (Ladefoged & Johnson, 2011).

3.2.2 Thai Vowels

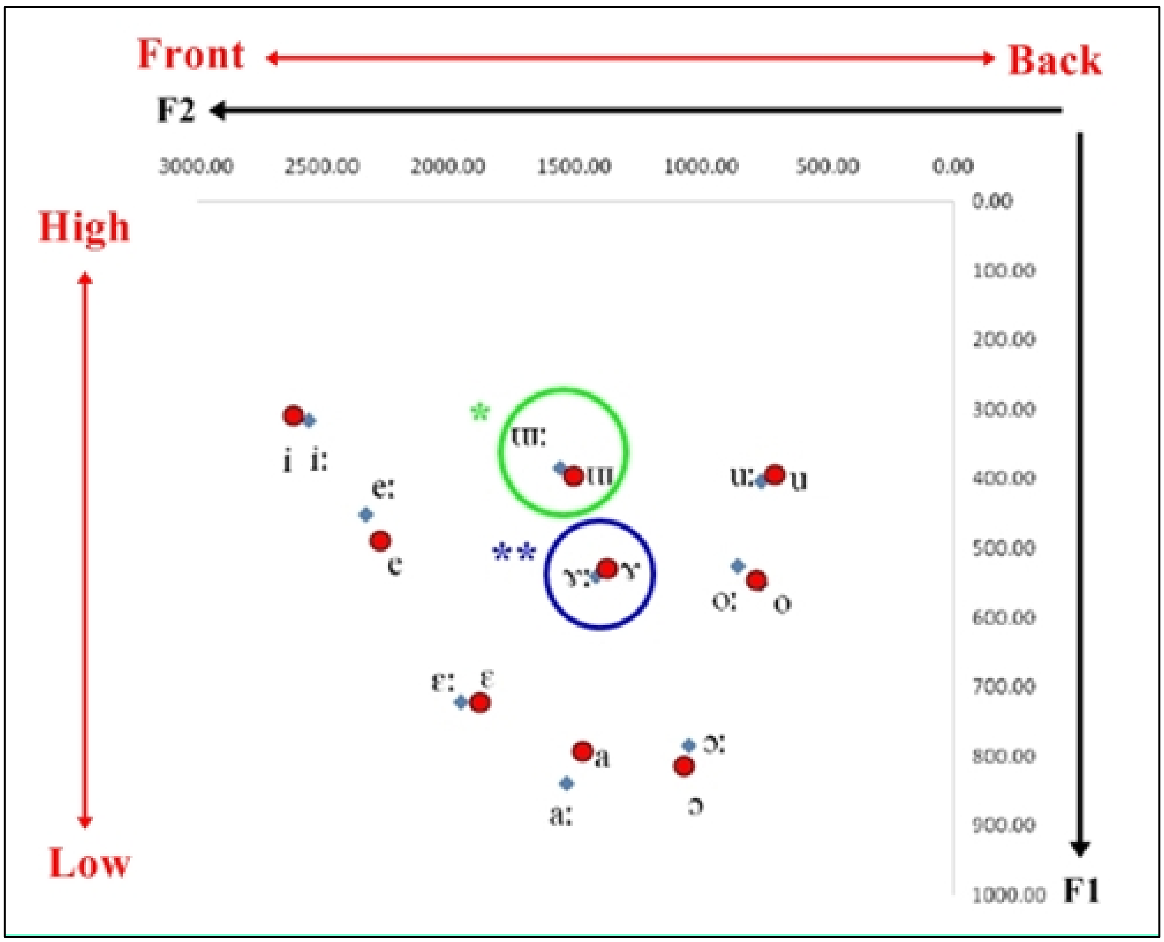


Figure 2-14: Thai Monophthongs Acoustic Chart (Tumtavitikul, 2015)

Figure 2-14 presents the relative relationship of Thai vowels in the acoustic vowel space. /ɯ/ and /ɯ:/ represent the high-back unrounded short and long vowels, respectively. These high-back unrounded vowels are close to the high-central unrounded vowels /ɨ/ and /ɨ:/. /ɤ/ and /ɤ:/ represent the mid-back unrounded short and long vowels in the Thai phonological vowel system. These mid-back unrounded vowel are close to the mid-central unrounded vowels /ə/ and /ə:/ (Tumtavitikul, 2015).

Vowels/ Vowel Duration (msec.)	Short Vowels	Long Vowels	Ratio Long/ Short Vowels
/i/, /i:/	145	298	2.05
/e/, /e:/	149	301	2.02
/æ/, /æ:/	168	332	1.97
/ɯ/, /ɯ:/	154	314	2.03
/ɤ/, /ɤ:/	175	332	1.89
/a/, /a:/	174	327	1.87
/u/, /u:/	150	321	2.14
/o/, /o:/	160	320	2
/ɔ/, /ɔ:/	165	334	2.02
Average	160	320	2

Table 2-7: Duration of Monophthongs in Thai (Roengpitya, 2001)

Table 2-7 presents the average duration of monophthongs in Thai from 3,240 tokens (130 tokens per each vowel) of both male and female Thai speakers (Roengpitya, 2001).

3.2.2.1 Thai Monophthongs

Thai has nine pairs of monophthong vowels with length contrast (i.e., short and long), which were written with 26 vowel letters but represent 18 vowel phonemes as shown in Table 2-6 and Figure 2-14. Table 2-7 shows that long vowels are about twice longer than short vowels. The average duration of all nine short vowels is 160 milliseconds (msec). And the average duration of all nine long vowels is 320 msec. (Roengpitya, 2001). Abramson's (1962) also found that Thai long vowels are 2 to 3.5 times longer than the short vowels. Examples of monopthongs in minimal/ near minimal pairs of short and long vowels are listed below (adapted from Panlay, 1997):

/i iː/	=	/ti/	'criticize'	vs.	/tiː/	'punish'
/ɯ ɯː/	=	/rɯ/	'or'	vs.	/rɯː/	'to raze/ demolish'
/u uː/	=	/du/	'scold'	vs.	/duː/	'watch'
/e eː/	=	/kreŋ/	'contract'	vs.	/kreːŋ/	'to be afraid of'
/ɤ ɤː/	=	/cɤʔ/	'meet'	vs.	/cɤː/	'meet'
/o oː/	=	/toʔ/	'table'	vs.	/toː/	'grow'
/æ æː/	=	/kæʔ/	'sheep'	vs.	/kæː/	'you' (a colloquial term)
/a aː/	=	/paʔ/	'paste'	vs.	/paː/	'throw'
/ɔ ɔː/	=	/kɔ/	'island'	vs.	'kɔː/	'classification of trees'

3.3 English Vowels vs. Consonants

Since one of the objectives of the current study is to see whether the training set technique also works with training consonants (i.e., onsets and codas), this section presents the differences and the similarities between vowels and consonants. Mannell (2015) pointed out that the differences between vowels and consonants can be explained in terms of physiological differences such as airflow and constriction, acoustic difference such as prominence, and phonological difference such as syllabicity. Physiologically, consonants generally have more constriction than vowels, except in the case of approximants (e.g., the semi-vowels /j/ and /w/). McCombs (2006) explained that vowels are different from consonants in that they are produced with little obstruction of airflow and that makes them sound different from consonants. Strange (2007) stated that different vowels are generally produced with the same active articulators (i.e., tongue body, lips, and jaws) and with a fairly open vocal tract, while consonants are produced in more varied locations and with more degree of constriction.

Acoustically, consonants are considered less prominent than vowels. Phonetically, vowel intensity has the tendency to be greater than the consonants that surround them. Although sometimes certain consonants can have a greater intensity than adjacent vowels, vowels are almost always more intense at low frequencies than adjacent consonants (Mannell, 2005). Burkle (2004) stated that consonants have higher frequency information (e.g., above 2000 Hz) than vowels, whereas vowel information ranges from low to moderate frequencies, which is below 2000 Hz. However, the approximants (e.g., /l ɹ/) have a low-intensity formant at a very low frequency (Ladefoged, 2005: 61). It has also been shown in many studies that the formant transitions and the spectral variation in vowels provide acoustic cues for both consonant and vowel identification (Cooper, Delattre, Liberman, Borst, & Gerstman, 1952; Halle, Hughes, & Radley, 1957; Liberman, Cooper, Shankweiler, & Studdert-Kennedy, 1967).

Phonologically, syllables generally consist of a vowel optionally surrounded by a number of consonants. The prominent nucleus of each syllable is formed by a single vowel. There is only one prominent peak for each syllable and that is almost always a vowel. Consonants can, in some cases, form a peak but it is less prominent than the vowel peaks, consonants in these cases are syllabic consonants. Syllabic consonants refer to the formation of a syllabic nucleus which does not contain a vowel. In English, syllabic consonants occur when a homorganic (same place of articulation) oral stop or sometimes a fricative precedes an approximant or a nasal stop, such as ‘bottle’ /bɔtl̩/ or ‘sudden’ /ˈsʌdn̩/. McCombs (2006) stated that since vowels are more sonorous and more acoustically powerful than consonants, vowels are perceived as both longer and louder than consonants. The fact that vowels are more sonorous permits them to form the basis of syllables.

In addition, Strange (2007) explained that phonetically vowels are different from consonants because vowels are perceived more continuously, whereas consonants are perceived categorically. Nishi and Kewley-Port (2007) contended that consonants and vowels require different types of perception training. They pointed out that when training consonants the investigated consonants generally contrast by only a single feature, such as voicing, manner, and place, however different vowels contrast by more than one feature, such as combinations of tongue height, tongue advancement, diphthongization, duration, lip rounding, rhoticity, etc. (Ladefoged, 1993, 2001). Moreover, the acoustic properties of vowels are influenced by many factors, for example, speaker's gender, age, dialect, and speaking styles (Ferguson & Kewley-Port, 2002; Hillenbrand, Getty, Clark, & Wheeler, 1995; Krause & Braida, 2002, 2004; Peterson & Barney, 1952).

4 Speech Production and Perception

This section presents the influential theories of speech production and Perception, which are applicable to this study. The speech production model presented in this section is Speech Learning Model (SLM) proposed by Flege (1995). And the speech perception model presented in this section is Perceptual Assimilation Model-L2 (PAM-L2) by Best & Tyler (2007). SLM and PAM-L2 models are specifically designed to cope with L2 learners' speech production and perception.

4.1 Speech Production Theory: Speech Learning Model (SLM)

Flege (1992) stated that the ways adults and older children learn the sound system of an L2 are different from young children acquiring their L1 in terms of speech apparatus and their native phonetic system for producing speech. Adults and older children have a more developed speech apparatus than young children do and their previously acquired structures could cause some errors in the production of their L2, which is referred to as "*phonetic interference.*" However, Flege tried to make the point that the foreign accent in the speech of adult L2 learners is not always from the maintenance of old articulatory habits. Rather, it is the effect of the existence of L2 sounds on L1 sounds. Thus, he pointed out many aspects of L2 production, which can be understood in terms of how L2 sounds are categorized. First, he discussed this based on production and perception mechanisms. He posited that the contrastive analysis (CA) approach predominantly used during the 1950s and 1960s, which suggested that cross-language differences are the major reasons causing speech learning difficulty, fails to predict which sounds would or would not be difficult. So Flege proposed two phonetic categories for the L2 sounds: the *similar* and the *new* categories.

For the *similar* category, it is the case that an L2 sound is identical to or similar to an L1 sound. If the L2 sound is identical to the L1, it may be produced authentically. For similar sounds the L1 sounds can often be substituted for the L2 sound without being noticed. The *new* category refers to L2 sounds that are substantially different from any L1 sound. Thus, such a new sound will not be identified as a sound in the L1 inventory. In addition to these two categories, he found that L2 learners have difficulty learning L2 sounds when L2 sounds have a counterpart in the L1 inventory, but they occur in an phonetic context or position not licensed in the L1 (e.g., word-initial position vs. word-final position). For instance, Spanish learners have more difficulty in producing English /s/ in word-final than word-initial position (Turitz, 1981 as cited in Flege, 1988).

Flege supported his hypotheses with both vowel and consonant studies. Mueller & Niedzielski (1963) showed that students enrolled in a French class were judged, by a native French-speaking listener, to have produced new French vowels (e.g., /y/) much better than similar vowels (e.g., /e/). These results corresponded to Flege's (1987) phonetic study, which showed that L1 English speakers of L2 French who had resided in Paris for 12 years produced French /y/ authentically, whereas the way L2 speakers produced /u/ is different from native French speakers. French /y/ has no phonological counterpart in English, while French /u/ is similar to English /u/ but different, because there are slightly differences in English /u/ such as not being fronted and is generally produced as a diphthong or with some movement. Moreover, many studies (e.g., Major, 1987 and Flege, 1992) have provided evidence that adult learners are able to master /æ/ if their L1 does not have such a vowel. Flege's 1992 study showed that the German and Dutch exhibited small but measurable differences from native speakers for similar English vowels, which are acoustically different from corresponding vowels in the L1. Based on these findings, he contended that his hypothesis (e.g., Flege 1987) is supported by the fact that L2 learners are unable to establish additional phonetic categories for similar L2 vowels because they are equated with L1 vowels.

Flege & Hillenbrand (1984) revealed that L1 French adults did not produce English /p, t, k/ as native speakers do. Similar results have been found in many other L2 production studies with subjects whose L1 has short-lag /p t k/. In those studies, adult L2 learners had tendencies to produce English /p t k/ with short-lag

VOT values or with negotiated values that are balancing between the VOT norm for /p t k/ in the L1 and the L2. There were very few results among those cases which were exceptions. As mentioned earlier, Flege contended that the foreign accent is not simply caused by “interference”, but it is the effect of the influence of L2 sounds on L1 sounds. His study in 1987 supported such a hypothesis by showing that Americans who were highly experienced speakers of French produced English /t/ with shorter, and more like French-like, VOT values than English monolinguals. The reversal pattern was found with highly experienced French speakers of English in Flege & Hillenbrand (1984) in that L1 French speakers of L2 English produced English-like stops in French.

Flege (1988) hypothesized that individuals who start learning the L2 around the age of five or six years old can proficiently manage to produce similar L2 sounds because they can establish separate phonetic categories for the target L1 and L2 sounds. This hypothesis was supported by Flege’s and Eefting’s (1987) study of Puerto Rican. In the study, only early learners were able to use all three modal VOT categories (i.e., lead, short-lag, and long-lag), while Spanish monolinguals, English monolinguals, and late L2 learners were able to produce only two of the three modal categories.

Based on what Flege and his colleagues have studied, they have developed a model called the speech learning model (SLM). This model aims to find the explanations for age-related limits on the ability to produce L2 sounds (i.e., vowels and consonants) in a native-like fashion. Flege (1995) proposed four postulates, which are currently related to SLM as follows:

Postulates

P1 The mechanisms and processes used in learning the L1 sound system, including category formation, remain intact over the life span, and can be applied to L2 learning.

P2 Language-specific aspects of speech sounds are specified in long-term memory representations called *phonetic categories*.

P3 Phonetic categories established in childhood for L1 sounds evolve over the life span to reflect the properties of all L1 or L2 phones identified as a realization of each category.

P4 Bilinguals strive to maintain contrast between L1 and L2 phonetic categories, which exist in a common phonological space. (Flege, 1995, 239)

These four postulates are presented comparatively with Best's & Tyler's (2007) Perceptual Assimilation for L2 learners' speech perception (PAM-L2) in the Section 4.2 below. Together with the four postulates, seven hypotheses related to SLM were also constructed (See Flege 1995 for details).

4.2 Speech Perception Theory: Perceptual Assimilation Model-L2 (PAM-L2)

Best & Tyler (2007) proposed the Perceptual Assimilation Model which takes into account L2 learners' speech perception (PAM-L2), as Best's original model focuses only on naïve listeners' speech perception. Best's (1995) original PAM proposed a set of assimilation patterns, which are based on gestural similarity between contrasts in L1 and L2, and which naïve listeners would use when first facing the new language. However, Best and Tyler (2007) extended the original PAM model to accommodate L2 perception. They explored how the findings from their model, nonnative speech perception, bear on phonological and phonetic aspects of L2 perceptual learning. In this model, not only the amount of exposure to the target language but also the phonetic properties of the language input provided to learners appears to interact with the developmental level and L2 learning status.

In PAM-L2, the perception of speech is considered as a function of linguistic experience in both naïve nonnative listeners and L2-learning listeners. For naïve nonnative listeners, their perception is systematically affected by detailed phonetic similarities and dissimilarities between native and nonnative phones and is not limited only to potential phonological distinctiveness. Furthermore, native phonotactic biases, coarticulatory patterns, and allophonic or other phonetic variations also systematically influence monolingual adults' perception of nonnative phonetic contrasts. Therefore, the conclusion was made that perception is not limited to differences that are relevant to native phonological contrasts, since adult monolinguals show systematically perceptual sensitivities to non-contrastive phonetic variation in both native and nonnative speech. With nonnative speech, some aspects of sensitivity to phonetic variation are related to similarities between nonnative stimuli and native speech patterns, while others reflect language-universal perceptual tendencies.

For L2-learning listeners, along the line of monolinguals, their perception of L2 contrasts is influenced systematically according to L1 phonotactic, allophonic, and coarticulatory patterning. As showed in the studies with naïve nonnative listeners, more recent L2 acquisition perception findings revealed that categorization and discrimination performance levels vary across L2 contrasts and across L1s by systematically relating to both the contrastive phonological and gradient phonetic properties of the L1s. The same implication also applies to different L1 dialects. Many studies on adults' perception of L2 contrasts have emphasized vowels, which differ greatly from consonants in terms of place constriction and the effect of language's rhythmic characteristics. However, findings on adults' perception of L2 vowels are often similar to those patterns found with L2 consonants.

They contended that listeners are able to learn L2 contrasts that are initially difficult to differentiate. Some evidence implies that perceptual training is influenced by familiarity with the L2 as showed in the comparison among native L2 speakers, relatively inexperienced listeners, and experienced listeners. Native speakers tend to categorize and discriminate certain nonnative L2 contrasts better than more experienced L2-learners and the more experienced learners will categorize and discriminate those contrasts significantly better than less experienced learners. They also found from many studies that perceptual skill level corresponds with accuracy in production of the L2 vowels. Additionally, they found from many studies that L2 usage and proficiency are related not only to increased L2 production experience, but also to increased L2 listening experience in meaningful conversation.

In their view, both PAM and SLM do not only take into consideration phonological contrasts in the L1 but also non-contrastive phonetic similarities and dissimilarities between L1 and nonnative/L2 phones. PAM agrees with SLM's P1 in that *the mechanisms and processes used in learning the L1 sound system, including category formation, remain intact over the life span, and can be applied to L2 learning*. However, PAM posits that perceivers extract invariants about *articulatory gestures* from the speech signal, rather than forming categories from *acoustic-phonetic cues*.

SLM's P2 posits that *language-specific aspects of speech sounds are specified in long-term memory representations called phonetic categories*. But, PAM rejects this assumption, which claims that expert perceivers develop abstract "categories". Rather, PAM contends that the listener directly perceives the articulatory gestures of the speaker, and they detect higher-order articulatory invariants through speech stimuli. PAM suggests that language-relevant speech properties can be differentiated at the phonetic level, at the higher-order phonological level, and at the lower-order gestural level. PAM considers *phonological categories* as minimal lexical differences in a given language, and considers *phonetic categories* as invariant gestural relationships that are sub-lexical, which do not signal lexical distinctions but provide perceptual information about the speaker's identity (i.e., positional allophones and differing realizations of a given phonological category across dialects or languages).

SLM's P3 states that *phonetic categories established in childhood for L1 sounds evolve over the life span to reflect the properties of all L1 or L2 phones* *identified as a realization of each category*. PAM agrees with SLM's P3 in the way that perceivers continue to refine their perception of speech gestures throughout the lifespan. However, Best & Tyler (2007) stated that P3 does not tell us how listeners identify nonnative phones as equivalent to L1 phones, and the level(s) at which this occurs. They mentioned that other models including SLM believe that perceivers search for proximal stimulus details (acoustic features), whereas PAM believes that perceivers search for distal event information. Thus, PAM-L2 posits that listeners may identify L1 and L2 sounds as functionally equivalent at the phonological level, and such phonological assimilation need not imply that the phones are perceived as identical at the phonetic level (e.g., French vs. English /r/).

SLM's P4 suggests that *bilinguals strive to maintain contrast between L1 and L2 phonetic categories, which exist in a common phonological space*. PAM-L2 agrees with SLM's P4 that L1 and L2 phonological categories exist in a common space, although the original PAM model, posits that both phonetic and phonological levels interact in L2 speech learning, and importantly, they depend on the relationship between the phonological spaces of the L1 and L2. The example of phonetic category differentiation results from contrasts at the phonological level is English and French phonetic categories for each of /p/ and /b/.

Best and Tyler (2007) demonstrated how PAM's framework could be extended to predict success at L2 perceptual learning by elaborating on four possible cases of L2 minimal contrasts that L2 learners initially perceive as speech segments. The first case is when *only one L2 phonological category is perceived as equivalent (perceptually assimilated) to a given L1 phonological category*. They explained that at the phonetic level, if only one member of the L2 contrast is perceived as a good exemplar of a given L1 category, then no further perceptual learning is likely to occur for it. All contrasts with other L2 categories would be either *two-category assimilations* or *uncategorized-categorized assimilations*. Thus, the learner would have little difficulty discriminating minimally contrasting words for those distinctions.

The second case is that *both L2 phonological categories are perceived as equivalent to the same L1 phonological category, but one is perceived as being more deviant than the other*. In PAM terms, this case would be considered a *goodness assimilation* contrast. The learners would be able to discriminate these L2 phones well, although not as well as *two category assimilation* types. The perceivers should also be able to easily recognize the lexical-functional differences between these L2 phones in minimal lexical contrasts. Thus, the new L2 phonological and phonetic categories for the deviant L2 phone will be eventually formed, while the L2 phone which is perceived as a better exemplar would be perceived phonologically and phonetically equivalent to the L1 category, without being learned as a new category.

The third case is *both L2 phonological categories are perceived as equivalent to the same L1 phonological category, but as equally good or poor instances of that category.* This case is equivalent to a *single-category L2 contrast assimilation* in PAM terms. At the initial stage of learning, the learner will have difficulty discriminating these L2 phones, which would be assimilated both phonetically and phonologically to the single L1 category, and minimally contrasting L2 phones would be perceived as homophones. Best and Tyler (2007) hypothesize that they would perceptually learn one of the L2 phones before they could establish a new phonological category or categories.

The fourth case is *no L1-L2 phonological assimilation*. In this case, if the contrasting L2 phones are not perceived by the naïve listener as belonging clearly to any single L1 phonological category and are instead perceived as having the combination of certain similarities to several L1 phonological categories (Uncategorized in PAM term). Thus, it may be relatively easy to learn one or two new L2 phonological categories perceptually. This seems to be similar to the *new* phone of SLM. However, in PAM's formulation, what needs to be taken in to consideration is not only the similarity or dissimilarity of a given L2 phone to the closest individual L1 phonetic category, but also its comparative relationships within the interlanguage phonological system. This phenomenon, therefore, can be affected by any other L1 phones that are perceived similarly, as well as the overlap between those L1 phones and the ones perceived similarly to the contrasting L2 phone. If each of these uncategorized L2 phones is similar to *different* sets of L1 phones, which means these uncategorized L2 phones are quite distant from one another within L1 phonological space, it should be easy for the listener to perceptually learn two new L2 phonological categories. However, if the uncategorized L2 phones are perceived similarly to the *same* set of L1 phonemes, which is to say that they are close to each other in phonological space, it should be difficult for the listener to discriminate these two L2 phones.

4.3 Production and Perception of English Sounds by Thai Learners

Corresponding to what has been studied previously (See Section 1.1), Thai (L1) learners also have difficulty acquiring some English (L2) sounds. It has been shown in many studies that L1-Thai learners of L2-English have difficulty producing and perceiving some English consonants and vowels. Those difficult consonants are /b g k l ɹ s v z θ ð tʃ ʃ/ (Allyn, 2013; Burkardt, 2005; Francis & McDavid, 1958; Jotikasathira, 1999, Hancin-Bhatt, 2000; Lerdpaisalwong & Park, 2012, 2013; Richards, 1967; Wei & Zhou, 2002), and the difficult vowels are /ɪ i ʊ u ɑ/ (Jotikasathira,1999; Richards, 1967; Tsukada, 2009; Varasarin, 2007). For the consonants, we can see that difficult consonant sounds, for the most part, do not exist in the Thai consonant inventory. In the few cases where these exist in Thai they are limited only in initial position (i.e., /b/) (see Table 2-3 on page 25-26). For the vowel sounds, we can see that most of the English vowels, which differ from Thai equivalents (i.e., /ɪ ɛ ʊ ʌ ɔ ɑ/), have been found to be difficult for Thai learners (see Table 2-6 on page 43).

Most of the studies focused on the production of difficult English sounds and not many studies have been conducted to investigate the perception of difficult English sounds. This is surprising because for most Thai students listening comprehension is the weakest skill, due to most elementary and high school teachers speaking only Thai and focusing on writing, grammar, and some reading more than any other skills (Noppakuthong, 2007 as cited in Allyn, 2013).

Allyn (2013) contended that the fundamental cause of listening and pronunciation problems began at the segmental level. The author believed that the phonemic differences between Thai and English are profound and are the major source of the difficulty in perceiving English sounds, which could affect the production of English sounds. The author then conducted a context sentence task with a multiple-choice test and a gap-fill test in order to test Thai learner's word perception of monosyllabic words and to analyze the locations of English phoneme errors. The morphemes investigated in the study are /v θ ð z ʃ tʃ/ for onset consonants, /d θ s ʃ tʃ/ for coda consonants, and /iː ɪ e ɛ ʊ ə/ for vowels. The results showed that unavailable phonemes, especially coda consonants and clusters, prevent learners from correctly perceiving those sounds. The average error was found to be highest in coda consonant clusters, vowels and coda consonants, and vowels and coda consonant cluster, respectively.

In general, the results from the pretest of the current study and previous studies on L1-Thai listener's perception of English stops suggest L1-Thai learners of L2-English would not have much difficulty perceiving English voiceless stops /p t k/ in the word final position, except for the cases of Thai EFLs that had English proficiency ranging from low to low intermediate. An example of this is Imsri & Idsardi (2002), who did a categorical perception task for English voiced stops /b g/, voiceless unaspirated stops /p k/, voiceless aspirated stops /p^h k^h/, and voiceless unaspirated stops /p k/ with Thai children and adult learners of English. They found that only Thai adult learners' perception is similar to that of the native speakers of American English.

Tsukada (2005) examined the discrimination of word-final stop contrasts (/p-t/ /p-k/ /t-k/) in English and Thai by groups of listeners differing in their L1: Australian English, Japanese, and Thai. The results showed that Thai listeners were able to discriminate both English and Thai word-final stops /p-t/ p-k/ /t-k/ accurately. Tsukada & Roengpitya (2008) studied the discrimination of words ending with voiceless stops /p t k/ in English and Thai by Thai speakers living in Australia, Thai undergraduates living in Thailand, and Thai high-school students living in Thailand. The results revealed that all three groups showed reasonably accurate discrimination for both English and Thai words.

Lerdpaisalwong & Park (2012) studied the perception of English stops in the syllable coda position by thirteen native Thai late learners of English as an L2. Thirteen Thai speakers' lengths of residency (LOR) range from1 to 23 years. The results showed that less than half of the speakers (i.e., five speakers with LOR1, LOR3, LOR5, LOR7, and LOR12) perceived every stop (i.e., /b d g p t k/) lower than 80 percent,[3] while more than half of the speakers (i.e., eight speakers with LOR4, LOR8, LOR8, LOR11, LOR18, LOR19, LOR19, and LOR23) perceived those six stops higher than 80 percent.

Lerdpaisalwong & Park (2013) investigated the perception of English coda stops by Thai EFL learners across three levels of English proficiency: Low,

[3] The 80 percent criterion is used here in order to provide a clear example when talking about learners' English proficiency. This criterion was originally used in the study of Cancino, Rosansky & Schumann (1978) and it has been widely adopted by many studies in the field of phonology.

Moderate, and High. The results revealed that Thai EFLs with the low level of English proficiency perceived every stop (i.e., /b d g p t k/) lower than 80 percent, while the high and the moderate proficiency levels perceived those six stops higher than 80 percent.

The present study trains Thai EFL learners with low intermediate English proficiency to perceive American English consonants and vowels using the training set technique adopted from Nishi and Kewley-Port (2007). The pretest perception scores revealed that Thai EFL learners, whose English proficiency is low intermediate, perceived the onsets /p t k/ higher than 80 percent, but they perceived the onsets /b d g/ and the codas /b d g p t k/ lower than 80 percent.

Although this study focuses on the speech perception training of difficult English sounds mentioned earlier, the difficult English sounds in production for Thai learners will be presented as well. That is because many studies have showed that after listeners go through perception training, they are able to generalize their new knowledge of the trained sounds to production. For instance, Bradlow et al. (1997) trained Japanese listeners to identify English /ɹ/ and /l/. After the training, Japanese listeners could transfer their improved perception ability of English /ɹ/ and /l/ to the production ability.

Lambacher et al. (2005) trained native speakers of Japanese to perceive American English (AE) vowels. Their results showed that a high variability identification training procedure (i.e., an identification training with multiple-talker stimuli) could improve native Japanese identification and production of AE mid and low vowels /æ/, /ɑ/, /ʌ/, /ɔ/, /ɝ/, as was shown in the improved performance of the participants after identification training with feedback. More importantly, the training also had a positive effect on their production of the target AE vowels.

I will now turn my attention to difficult English sounds for L1-Thai leaners of L2 English in production. As mentioned earlier, many studies have been conducted to examine the difficult English sounds in production by Thai learners. Burkardt (2005) found that Thai learners of English as an L2 mostly replaced the voiceless interdental fricative /θ/ in a reading list with /t/, /ð/, /d/, /f/, /v/ or deleted the sound. For the voiced interdental fricative /ð/ in the same task, Thai ESL learners tended to replace mostly with /d/, /θ/, and /t/, respectively. The subjects pronounced both /ð/ and /θ/ more accurately in the reading list than in a reading passage, and, they pronounced the voiceless interdental fricative more correctly when compared to the voiced one. Most errors in the reading list occur with the voiceless /θ/ in word medial position. It was correctly pronounced more often in the word final position, and it was almost always correctly pronounced in word initial position. Errors with the voiced /ð/ occurred, from most to least often, in word initial position, in word final position, and in word medial position.

Jotikasathira (1999) pointed out three types of difficult English sounds for Thai learners to pronounce. The first type is sounds that do not occur in Thai (i.e., /v θ ð z ʃ ʒ g dʒ/). The second type is sounds that do not occur in the final position (i.e., /l f s b d/). And the third type is sounds that are phonetically different from Thai equivalents (i.e., /ɹ i e u o/). Francis & McDavid (1958) explained that English /ɹ/ can be formed differently depending on different speakers and dialects. For instance, retroflex and bent back is common throughout the midland area, while the Thai /r/ sound is trilled. Wei & Zhou (2002) reported that English /ɹ/ is usually pronounced as /l/. /θ/ or /ð/ are pronounced as /s/ or /z/, /v/ is pronounced as /f/, and, /z/ is pronounced as /s/.

Richard (1968) studied the pronunciation features of Thai speakers of English living in New Zealand. He contended that the interference in the form of differing phonetic representation of corresponding phonemes in English and Thai is a major source of pronunciation difficulty, as well as the different distribution between phonemes in English and Thai. He pointed out that English /ɪ/ becomes /ɨ/ or /i/, /ɑ/ becomes /o/, and /ʊ/ becomes /u/. Although the English vowels investigated in this study are New Zealand English, these vowels in American English were also found to be difficult for Thai learners (Varasarin, 2007; see also Table 2-6).

For initial consonant sounds, he found that Thai learners substituted /tʃ/ and /ʃ/ with /c^h/, /v/ with /w/, /θ/ with /t/ or /s/, /ð/ with /d/, /z/ with /s/, /r/ with /l/, and /b, d, g/ with less voicing sounds. The degree of voicing used to differentiate the voiced and voiceless labial and dental plosives in both Thai and English has been found to be significantly different. The final consonant sounds, /d t tʃ ʃ ð θ z s/ when not omitted, are replaced by an unreleased voiceless dental plosive /t̚/. /b/ and /p/, when not omitted, are replaced by an unreleased voiceless bilabial plosive /p̚/. /k/ and /g/ are replaced by an unreleased voiceless velar plosive /k̚/. /f/ and /v/ when not omitted, are replaced by an unreleased voiceless bilabial plosive /p̚/. /l/ is replaced by /n/ because Thai phoneme /n/ in final position is symbolized in the Thai orthography by the same symbol as for Thai initial /l/.

Tsukada (2009) studied the durational characteristics of English vowels produced by Thai L2 learners living in Australia. The results showed that Thai speakers differentiated the duration of the two vowels, /i - ɪ/, to a greater extent than did the Australian English speakers. In other words, Thai speakers produced /ɪ/ too short and /i/ too long compared to those of Australian English. Thus, she suggested that Thai speakers need to be made aware that the English short vowels are not as short as the Thai short vowels and that the English long vowels are not as long as the Thai long vowels.

Hancin-Bhatt (2000) investigated the production of English coda segments by intermediate L1 Thai ESL learners in the US. The results showed that Thai ESL learners had difficulty producing voiced stops in coda (i.e., /b d g/). The percentage of correctness of the voiced stops was 67%, while the percentage of correctness of voiceless stops, fricatives, and nasals were higher than 80 percent. Likewise, Lerdpaisalwong & Park (2013) investigated the production of English coda stops by Thai EFL learners in Thailand across three different levels of English proficiency: Low, Moderate, and High. The results showed that Thai EFL learners with every level of English proficiency produced /b/ and /g/ lower than 80 percent; the low proficiency group produced every coda stop (i.e., /p t k b d g/) lower than 80 percent and the moderate proficiency group produced /k/ at exactly a 79 percent rate. Based on the information from the previous studies and the pretest of the recent study, Thai L1-learners of L2-English have difficulty perceiving and producing English consonants /b g k l ɹ s v w z θ ð tʃ ʃ/ and vowels /ɪ i ʊ u ɑ/. Therefore, these English consonants and vowels will be examined in the present study, except diphthongs (see Appendix A). Diphthongs will be explored in a future study.

Difficult English Sounds in Production		
Vowels	**Consonants**	
	Initial and Medial Position	Final Position
Australian English - /eɪ oʊ/ (Tsukada, 2008) - /i/ (too short) and /ɪ/ (too long) (Tsukada, 2009) English - /i, e, u, o/ (Varasarin, 2007) - /eɪ/ (Wei & Zhou, 2002) New Zealand English (Richard, 1968) - Monophthongs /ɪ ɑ ʊ ɜ/ - Diphthongs /ej aj ɔj əw aw/ (when pronounced with codas) - Diphthongs /er ur ɔr/	American English - /θ ð/ (Burkardt, 2005) - /ɹ/ (Francis & McDavid, 1958) English - /ɹ θ ð z ʒ/ (Wei & Zhou, 2002) New Zealand English - /g k tʃ ʃ dʒ ʒ v θ ð z l ɹ/ (Richards, 1968)	American English - /θ ð/ (Burkardt, 2005) - Cluster consonants: liquid nasal (*deerm*), liquid stops (*nalt*), liquid fricatives (*farf*) (Hancin-Bhatt, 2000: less than 80% when using 80% criteria) - Voiced stops /b d g/ (Hancin-Bhatt, 2000: less than 80% when using 80% criteria) English - /l f s p b t d k/ (Jotikasathira, 1999) - /v z/ (Wei & Zhou, 2002) New Zealand English - /d t tʃ dʒ ʃ ʒ θ ð s z b p k g f v l/ (Richards, 1968)

Table 2-8: Difficult English Sounds in Production for Thai ESLs/ EFLs

Table 2-8 summarized the English vowels and consonants found to be difficult in production for Thai ESLs and EFLs. Table 2-9 summarized the English vowels and consonants found to be difficult in perception for Thai ESLs and EFLs.

Difficult English Sounds in Perception		
Vowels	**Consonants**	
	Initial and Medial Position	**Final Position**
- Monophthongs /ɪ ɛ ʊ ə/ and diphthong /eɪ/ (Allyn, 2013) - The results from the pretest of the present study showed that Thai EFLs with low intermediate English level proficiency could perceive /i ɪ u ʊ ɛ ɑ ʌ æ ɔ/ lower than 80% with the lowest scores for /ɑ ʌ ɔ/ which are considered "Difficult segments" for the present study.	- The results from the pretest of the present study showed that Thai EFLs with low-intermediate English level proficiency could perceive the onsets /b d g/ lower than 80%	- All phonemes that do not exist in Thai phonemic inventory (Allyn, 2013) - Cluster consonants: liquid nasal (*deerm*), liquid stops (*nalt*), liquid fricatives (*farf*) (Hancin-Bhatt, 2000: 5 out off 11 subjects got lower than 80%) - Thai speakers with LOR1, LOR3, LOR5, LOR7, and LOR12 perceived /b d g p t k/ lower than 80% (Lerdpaisalwong & Park, 2012) - Thai EFLs with low English level proficiency could perceive /b d g p t k/ lower than 80% (Lerdpaisalwong & Park, 2013) - The results from the pretest of the present study showed that Thai EFLs with low-intermediate English level proficiency could perceive /b d g p t k/ lower than 80%

Table 2-9: Difficult English Sounds in Perception for Thai ESLs/ EFLs

5. Current Study

The speech perception training studies mentioned previously (See pages 11-23) suggested many factors, which help make speech perception trainings effectively improving L2 leaners' perception of difficult L2 sounds. Those factors are an intensive laboratory training, highly variable naturally produced stimulus (HVNP), an identification task for training sessions, subject-controlled stimulus presentation, an immediate feedback, and long-term training (Lively et al., 1993; Logan et al., 1991; Logan & Pruitt, 1995; Nishi & Kewley-Port, 2007, 2008; Pruitt et al., 2006; Strange, 1992) (See Table 2-1). Nishi & Kewley-Port (2007) reported that those factors worked even more effectively with vowels when training L1-Japanese learners of L2-English with both difficult and easy vowels, rather than training them with only difficult vowels. One possible reason they suggested this, is that the trainees were exposed to more various acoustic cues among different vowels within the training set. The training which includes both difficult and easy segments was referred to in their study as "Fullset" training. And the one that includes only difficult segments was referred to in their study as "Subset" training. In the follow-up study, Nishi & Kewley-Port (2008) conducted another perceptual training session using the same technique (i.e., Fullset vs. Subset trainings) to train Korean adult L2 learners of English. They reported the same finding: the Fullset training worked better than the Subset training also with Korean L2 learners of English.

This study, therefore, aims to find answers for the following research questions:

1. Can the laboratory perceptual training using the full set training suggested in Nishi & Kewley-Port (2007) also be applied to L1-Thai learners' perceptual training of L2-English vowels?
2. Can the training set technique also be applied to the L1-Thai learners' perceptual training of L2-English *consonants*?

   2.1 If it can, do phonological contexts (i.e., onsets and codas) matter?
3. What will be the patterns of the interaction between the training set and the segment investigated in each learner? More specifically,

   3.1 Which training set will be more effective in training listeners' easy and difficult vowels?

   3.2 Which training set will be more effective in training listeners' easy and difficult consonants?

   3.3 Which training set will be more effective in training the easy and difficult vowels?

   3.4 Which training set will be more effective in training the easy and difficult consonants?
4. Will L1-Thai learners of L2-English be able to generalize the training to a new talker?

Regarding the first question, I predict that the set training technique suggested in Nishi & Kewley-Port (2007, 2008) will also apply to work for the perceptual training of L1 Thai learners of L2-English. The Fullset training with both difficult and easy English vowels will be more effective than the Subset training only with difficult English vowels. This prediction is based on Nishi &

Kewley-Port's (2007, 2008) findings, an L1 difference did not influence the results. L1-Japanese learners and L2-Korean learners did not show any difference from the suggested trainings although their language backgrounds differ from each other.

Regarding the second question, I predict that the results and the patterns for consonants will be different from those for vowels, following the reasoning suggested by Nishi & Kewley-Port (2007) that vowel and consonant have different characteristics. As pointed out by Nishi & Kewley-Port (2007), a group of consonants can be minimally distinguished by only one feature: voicing, manner, or place. However, any two-vowel contrast usually involves more than one feature (e.g., various combinations of tongue height, tongue advancement, diphthongization, duration, lip rounding, rhoticity, etc., (Ladefoged, 2001, 2011)). Moreover, compared to consonants, the acoustic properties of vowels can be influenced more by speakers' gender, age, and dialect (Hillenbrand, Getty, Clark, & Wheeler, 1995; Peterson & Barney, 1952) as well as speaking styles (Ferguson & Kewley-Port, 2002; Krause & Braida, 2002, 2004). Thus, vowels and consonants possess different characteristics.

Regarding the third question, I do not have specific predictions because of the nature of the question. I would like to describe individual differences among the learners and the segmental differences as a whole within the language system. Regarding the fourth question, I expect to see the generalization to a new talker as in previous studies (Lively et al., 1993). The results for each question will be discussed in Chapter 5 (See pages 164-183).

Chapter 3

Methodology

1. Participants

Participants were 93 L1-Thai learners of L2-English. There were both male and female participants, whose ages ranged from 18 to 24 years old (M = 47; F = 46). All participants were undergraduate students at Kasetsart University, Bangkok, Thailand. They were students of Foundation English II, and their English language proficiency was low intermediate. They were placed in the course (i.e., Foundation English II) based on their English scores from a national entrance examination, which is a standardized test. They were randomly assigned to one of the following nine perception-training groups. Thus, there were about ten participants in each perception group.

- Experimental group 1: Onset Fullset (N = 10)
- Experimental group 2: Onset Subset (N = 10)
- Control group 1: Onset Control (N = 11)
- Experimental group 3: Coda Fullset (N = 9)
- Experimental group 4: Coda Subset (N = 10)
- Control group 2: Coda Control (N = 11)
- Experimental group 5: Vowel Fullset (N = 9)
- Experimental group 6: Vowel Subset (N = 10)
- Control group 3: Vowel Control (N = 13)

None of the Thai participants had traveled extensively in an English-speaking country prior to the experiment. Six native speakers of American English were recruited to produce the stimuli for the perception task. Five are Midwesterners and one is originally from Maryland but has resided in the Midwest for his entire adult life. The ages of speakers ranged from 21 to 70 years old. All participants, both Thais and native speakers of American English, had no history of speech or hearing disorders.

2. Stimuli

For real words (RW, henceforth), the stimuli were 96 **C**VC with 16 onsets (i.e., /b p d t k g r l s z v w ð θ tʃ ʃ/) (16 onsets x 6 words = 96), 96 CV**C** with 16 codas (i.e., /b p d t k g r l s z v f ð θ tʃ ʃ/) (16 codas x 6 words = 96), and 72 C**V**C with 9 vowels (i.e., /i ɪ ɛ æ ɑ ɔ ʊ u ʌ/) (9 vowels x 8 words = 72) (see Appendix 1). The two words from each stimulus (i.e., 16 onsets x 2 words = 32, 16 codas x 2 words = 32, and 9 vowels x 2 = 18 tokens) were used as familiarization words in the familiarization task.

Nishi & Kewley-Port (2007: 1498) controlled the use of consonants in the monosyllabic consonant-vowel-consonant ($\mathbf{C}_1\mathrm{V}\mathbf{C}_2$) real words, which were used in training vowels by using only the ones that are comparable categories in Japanese so that listeners did not have to learn new consonants. However, in the present study, various types of vowels were incorporated so that listeners would be trained with naturalistic and various possible sequences of consonants and vowels. At the same time, the familiarity of the word was controlled. Additionally, Thai restricts possible consonants in coda due to neutralization. Because of such restriction and familiarity control, it is difficult to use only consonants and vowels that are comparable categories in Thai. Therefore, the sounds that seem to be familiar to Thai listeners but do not exist in the Thai consonant inventory were also included. To illustrate, Thai does not have coda /f s/ nor the phonetic equivalents for /ɑɪ ɔɪ ɑʊ oʊ eɪ/.[4] However, /f s/ sounds, as well as those diphthongs, are used in some English loanwords in Thai (Noss, 1964). Thus, the codas /f s/ were also used as a second consonant in the monosyllabic consonant-vowel-consonant ($C_1V\mathbf{C_2}$) real words, which were used in training vowels, and the diphthongs /ɑɪ ɔɪ ɑʊ oʊ eɪ/ were also used in the monosyllabic consonant-vowel-consonant ($C_1\mathbf{V}C_2$) real words, which were used in training onsets and codas.

For nonsense words (NSW, henceforth), the stimuli were 64 **C**VC with 16 onsets (i.e., /b p d t k g r l s z v w ð θ tʃ ʃ/) (16 onsets x 4 words = 64), 64 CV**C** with 16 codas (i.e., /b p d t k g r l s z v f ð θ tʃ ʃ/ (16 codas x 4 words = 64), and 54 $C_1\mathbf{V}C_2$ə with 9 vowels (i.e., /i ɪ ɛ æ ɑ ɔ ʊ u ʌ/) (9 vowels x 6 consonantal contexts = 54), where C_1-C_2 combinations were /b-b, b-p, d-d, d-t, g-g, g-k/ (see Appendix A). Nonsense words are crucial for perception trainings, because it assures us that participants' improvement after the training is due to the training, not their knowledge of word spelling.

[4] Thai also has some diphthong-like sequences that many scholars do not traditionally analyzed as diphthongs. For instance, Nacsakul (1998) suggested that these sequences should be treated as a single vowel closed by a glide /-j/ or /-w/ (i.e., /aj a:j aw a:w iw ew e:w ɛw ɛ:w uj o:j ɔj ɔ:j/). Although some scholars, such as Brown (1993), treat these sequences as diphthongs, they are more restricted in distribution than the (true) diphthongs (e.g., /ia ɯa ua/) in Thai, and will be treated merely as sequences of V(V) + glide rather than as true diphthongs in this dissertation.

No stimulus started (i.e., onsets) or ended (i.e., codas) with difficult sounds (e.g., sounds which do not exist in Thai phonemic inventory and/or which are not familiar to Thai listeners) so that participants did not have to cope with this and could concentrate on the training. Also, no minimal pairs were used in the stimuli to avoid different degrees of confusability and difficulty. It is because the words that have minimal pairs tend to be more confusable and more difficult for listeners compared to the words that do not have the minimal pairs.

For consonants (e.g., both real words and nonsense words), two male (M1 and M2) and one female (F1) native speakers of American English produced the stimuli by reading a list of sentences aloud, and they were recorded. Since multiple talkers can enhance the perception training, more than one native speaker of American English produced the stimuli (Logan et al., 1991). The list of sentences was shown to the talkers on a Powerpoint slide with a seven second interval between each sentence (slide) in order to control the speech rate, which might affect the production of the segments investigated. The carrier sentences including target stimuli as follows, *"The first word is ___, isn't it?"* with a falling intonation before the tag question. The sentences were recorded at 44.1 kHz in a sound booth in the Department of Linguistics' Phonetics lab using a head-mounted microphone (SHURE SM10A).

Target words were isolated from the talkers' sentence productions. These target words were divided into four blocks: Onset Real Word, Onset Nonsense Word, Coda Real Word, and Coda Nonsense Word blocks. Each block consisted of the same tokens produced by the three talkers. And, the total number of tokens in each block was 288 for real words (= 16 onsets/codas x 6 words x 3 speakers) and 192 for nonsense words (= 16 onsets/codas x 4 words x 3 speakers).

The productions for each block were randomized and presented to two native speakers of American English (one male and one female) with 0.5 seconds inter-stimulus interval. Each rater rated four blocks by using Praat version 5.3.04. The raters listened to the target stimuli via headphones (Sony MDR-ZX 100) and selected the sounds they heard among the choices /b p d t k g r l s z v w ð θ tʃ ʃ/ on a computer screen. Then, the rating results from the two raters were compared. Agreement between the two raters was used as a criterion for the reliability of the tokens. Only stimuli correctly rated by both raters were used in the experiment.

For vowels (e.g., both real words and nonsense words) (See Appendix A), three experienced linguists (F2, M3, and M4), who are native speakers of American English, produced the stimuli by reading a list of sentences aloud, and they were recorded. The recording procedure was the same as for the consonant stimuli. The list of sentences were shown to the talkers on a Powerpoint slide with a seven second interval between each sentence (slide) in order to control the speech rate, which might affect the production of the segments investigated. The list consisted of carrier sentences including target stimuli as follows, *"The first word is ___, isn't it?"* with a falling intonation before the tag question. The sentences were recorded at 44.1 kHz in a sound booth in a phonetic lab using a head-mounted microphone (SHURE SM10A). The familiarity of most stimuli (i.e., both words for consonants and vowels) was 7 out of a 7-point rating scale of familiarity in the Hoosier Mental Lexicon (Nusbaum, Pisoni, & Davis, 1984).

3. Procedures

3.1 Experimental Schedules

This study included six sessions. In the first session, subjects participated in a production pretest task (part of a separate study). The second session was a familiarization task. The third session was a perception pretest task. The fourth task involved perception training across seven sessions (one per day) of approximately 25 minutes each. The fourth task was only for the six experimental groups (i.e., onset fullset, onset subset, coda fullset, coda subset, vowel fullset, and vowel subset) but not the control groups. The fifth session was a production posttest (part of a separate study). Finally, the sixth session was a perception posttest. The production pretest and posttest tasks had participants undertake sentence reading tasks. The perception pretest and posttest tasks involved a word-listening task (an identification task). The training session was also an identification task, but with immediate feedback. The results from the production will be reported in a separate study. All six of the sessions took place at Kasetsart University Self Access Language Learning Center (KU-SALL). Table 3-1 presents the details of this study's procedure, which consists of the six sessions mentioned earlier and the number of participants.

Group	Experimental Schedules																
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17
Onset Fullset (N=10)	Intro	Pro-Pre	Pro-Pre	Pro-Pre	Familiarization Task	Per-Pre	---------------------- Perception Training ------------------------							Per-Post	Pro-Post	Pro-Post	Pro-Post
Onset Subset (N=10)	Intro	Pro-Pre	Pro-Pre	Pro-Pre	Familiarization Task	Per-Pre	---------------------- Perception Training ------------------------							Per-Post	Pro-Post	Pro-Post	Pro-Post
Onset Control (N=11)	Intro	Pro-Pre	Pro-Pre	Pro-Pre	Familiarization Task	Per-Pre								Per-Post	Pro-Post	Pro-Post	Per-Post
Coda Fullset (N=9)	Intro	Pro-Pre	Pro-Pre	Pro-Pre	Familiarization Task	Per-Pre	---------------------- Perception Training ------------------------							Per-Post	Pro-Post	Pro-Post	Pro-Post
Coda Subset (N=10)	Intro	Pro-Pre	Pro-Pre	Pro-Pre	Familiarization Task	Per-Pre	---------------------- Perception Training ------------------------							Per-Post	Pro-Post	Pro-Post	Pro-Post
Coda Control (N=11)	Intro	Pro-Pre	Pro-Pre	Pro-Pre	Familiarization Task	Per-Pre								Per-Post	Pro-Post	Pro-Post	Per-Post
Vowel Fullset (N=9)	Intro	Pro-Pre	Pro-Pre	Pro-Pre	Familiarization Task	Per-Pre	---------------------- Perception Training ------------------------							Per-Post	Pro-Post	Pro-Post	Pro-Post
Vowel Subset (N=10)	Intro	Pro-Pre	Pro-Pre	Pro-Pre	Familiarization Task	Per-Pre	---------------------- Perception Training ------------------------							Per-Post	Pro-Post	Pro-Post	Pro-Post
Vowel Control (N=13)	Intro	Pro Pre	Pro Pre	Pro Pre	Familiarization Task	Per-Pre								Per-Post	Pro-Post	Pro-Post	Per-Post

Table 3-1: Experimental Schedules

3.2 **Familiarization Task** (Adapted from Nishi & Kewley-Port, 2007)

Prior to the pretest, all listeners were familiarized with the response alternatives and software used in all sessions. First, the listeners' familiarity with the key words (32 key words for onset group; 32 key words for coda group; 18 key words for vowel group) (see Figures 3-1 to 3-4) shown on the computer interface had to be confirmed. Then, the same interface used during tests and training with key word speech samples recorded from Speaker 1 (i.e., F1) were presented. The interface displayed International Phonetic Alphabet (IPA) symbols for the sixteen onsets, the sixteen codas, and the nine target vowels and two key words below each symbol. The experimenter reminded the listeners that their task during familiarization was not to identify the onsets, codas, or vowels in key words but to memorize the relationship between each IPA symbol and key words. Speech samples for key words were presented four times - twice in a fixed order first, then two more times in a random order. The listeners were asked to indicate the key word that they heard by clicking on an IPA symbol button. The followings are steps in the familiarization task.

Step 1: Click “Sound Test” button to test the volume
(see Figure 3-1 below)

Step 2: Click “Start” button to start
(see Figure 3-1 below)

Step 3: Click at the IPA symbol of the sound you heard
(see Figure 3-2 below)

Step 4: The task has finished
(see Figure 3-3 below)

Step 5: Look at reported scores on Home Page
(see Figure 3-4 below)

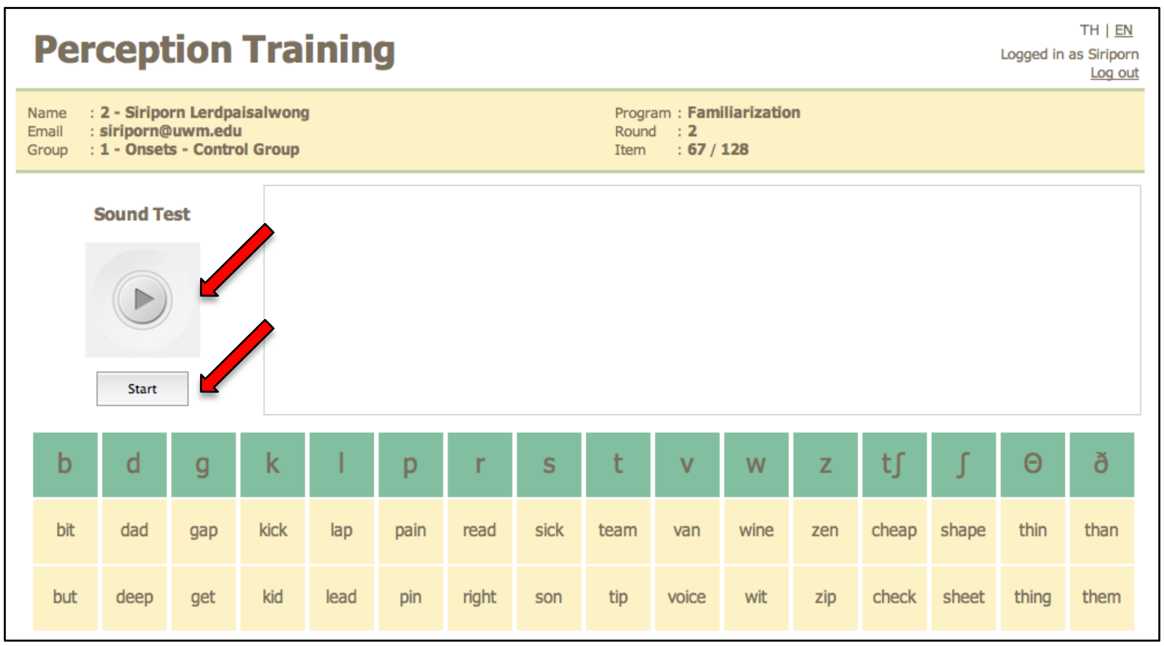


Figure 3-1: Familiarization Task Interface Step 1 and 2

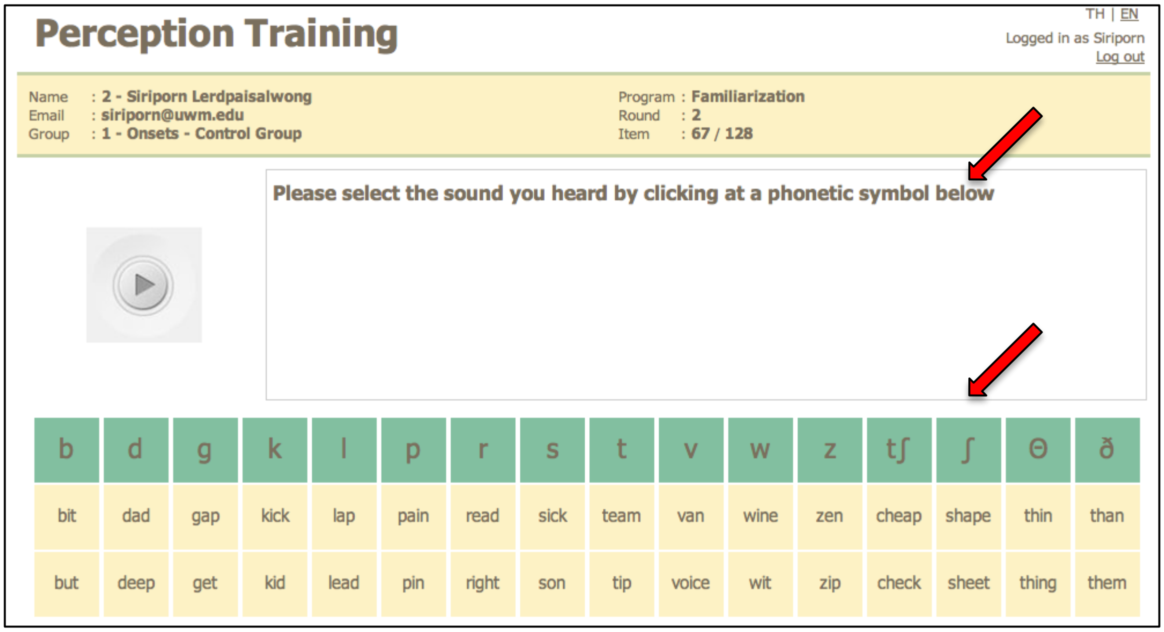


Figure 3-2: Familiarization Task Interface Step 3

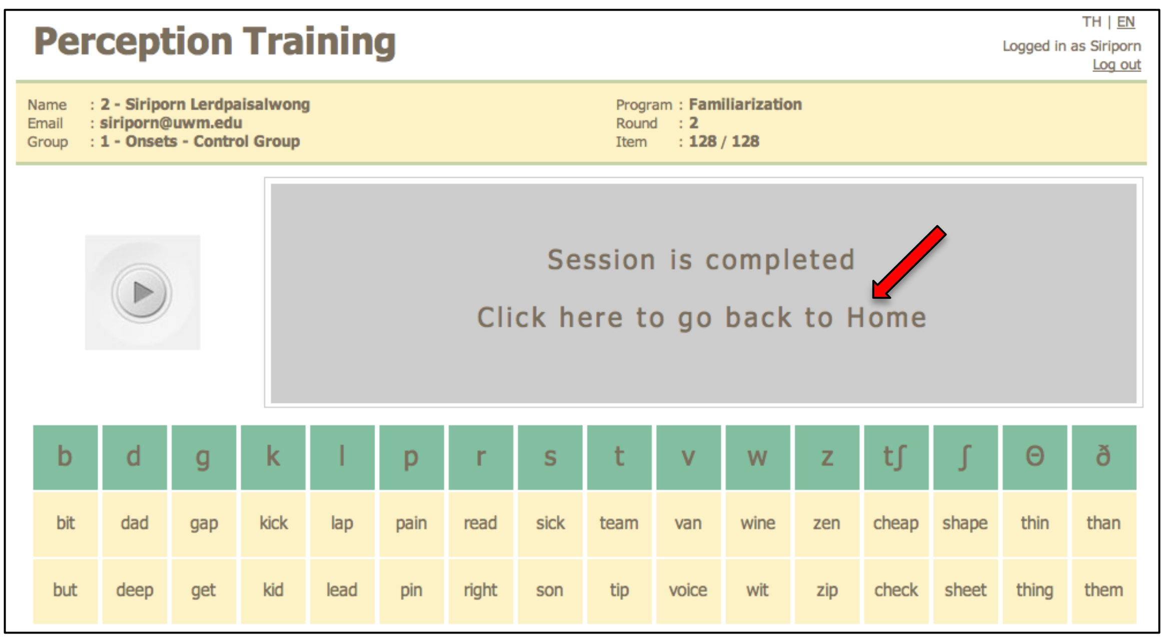


Figure 3-3: Familiarization Task Interface Step 4

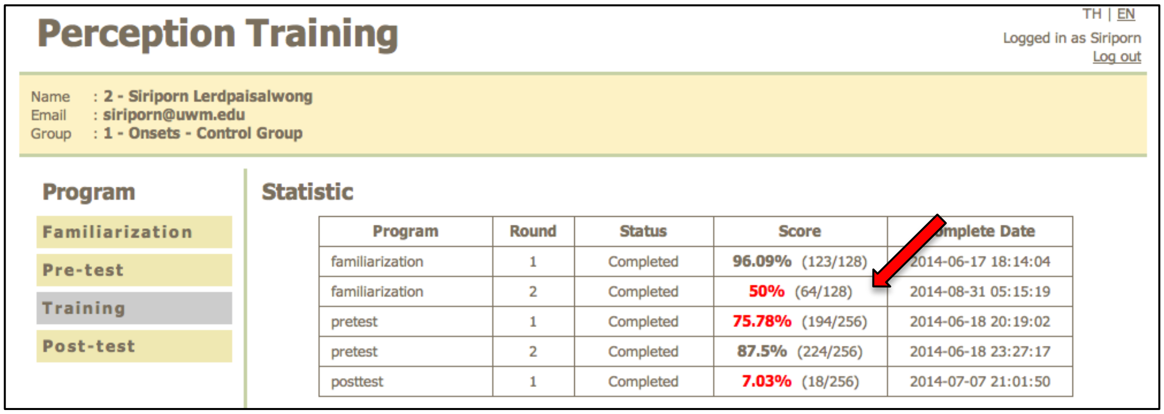


Figure 3-4: Familiarization Task Reported Scores on Home Page Step 5

3.3 **Perception Pre- and Posttests** (Adapted from Nishi & Kewley-Port, 2007)

The same four blocks (i.e., two RW vowel blocks and two NSW vowel blocks) of listening tasks were given to the three vowel groups: Fullset, Subset, and Control groups. The same four blocks (i.e., two RW onset blocks and two NW onset blocks) of listening tasks were given to the three onset groups: Fullset, Subset, and Control groups. And the same four blocks (i.e., two RW coda blocks and two NSW coda blocks) of listening tasks were given to the three coda groups: Fullset, Subset, and Control groups. Stimulus materials were blocked according to speaker. Half of the listeners in each group began the task with M1 (i.e., Speaker 2) for onsets and codas, followed by M3 (i.e., Speaker 5) for vowels first, M2 (i.e., Speaker 3) for onsets and codas, and M4 (i.e., Speaker 6) for vowels for both real and nonsense words, in that order. The other half of the listeners in each group began the listening task with M2 for onsets and codas, followed by M4 for vowels first, M1 for onsets and codas, and M3 for vowels for both real and nonsense words, in that order. The perception pretest was done before the training sessions and the perception posttest was done after the training sessions. Pre- or posttests were not given on the same day as training.

The following steps constitute the perception pretest task. The same steps were conducted in the perception posttest task after the 7-day trainings.

Step 1: Click “Sound Test” button to test the volume
(see Figure 3-5 below)

Step 2: Click “Start” button to start
(see Figure 3-5 below)

Step 3: Click at the IPA symbol of the sound (real words) you heard
(see Figure 3-6 below)

Step 4: Click at the IPA symbol of the sound (nonsense words) you heard
(see Figure 3-7 and 3-8 below)

Step 5: The task has finished
(see Figure 3-9 below)

Step 6: Look at reported scores on Home Page
(see Figure 3-9 above)

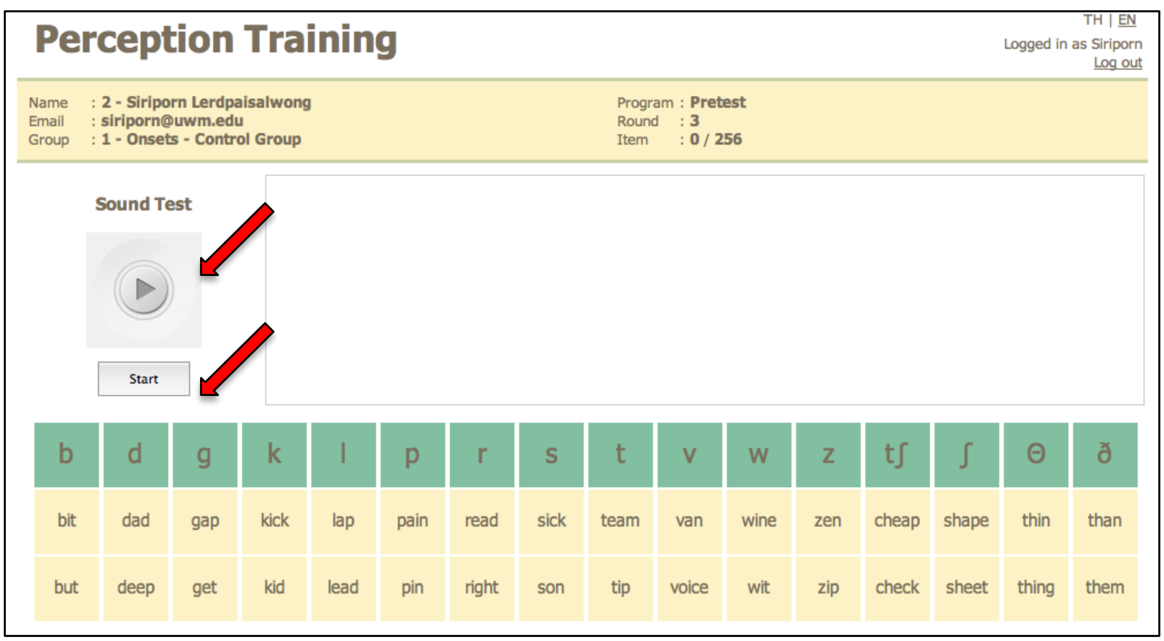


Figure 3-5: Pretest and Posttest Task Interface Step 1 and 2

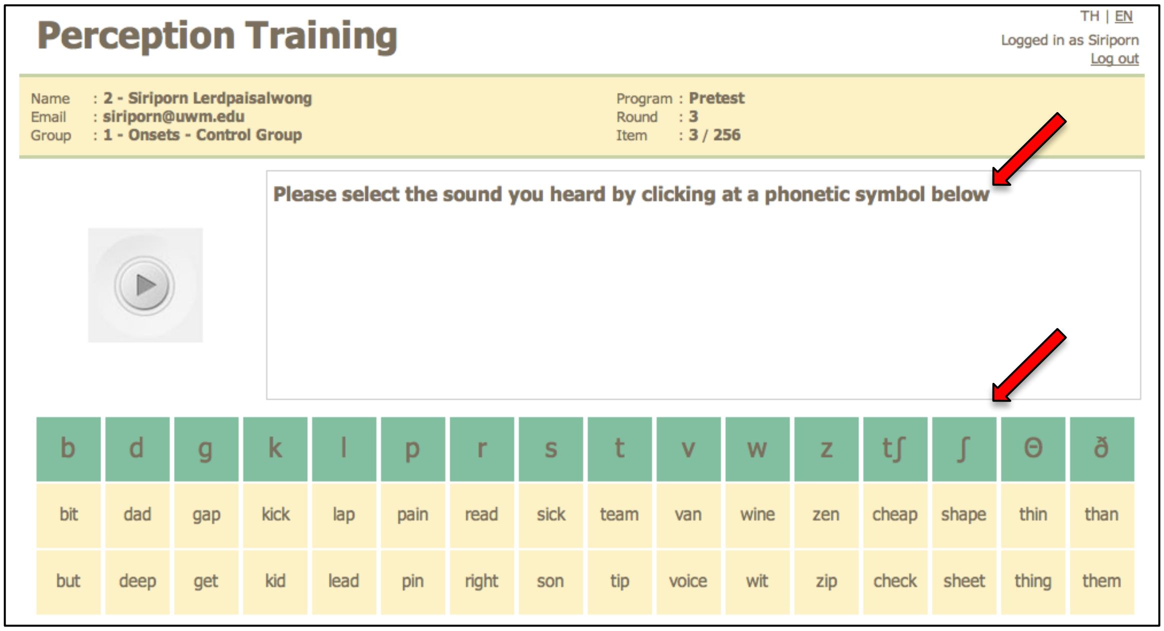


Figure 3-6: Pretest and Posttest Task Interface Step 3

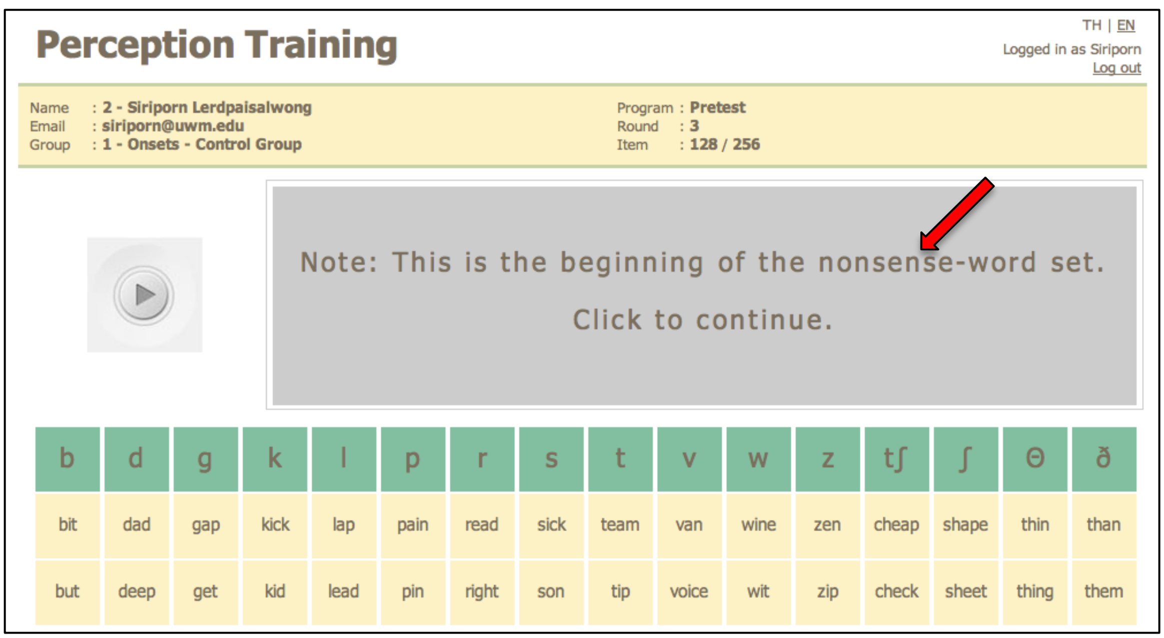


Figure 3-7: Pretest and Posttest Task Interface Step 4

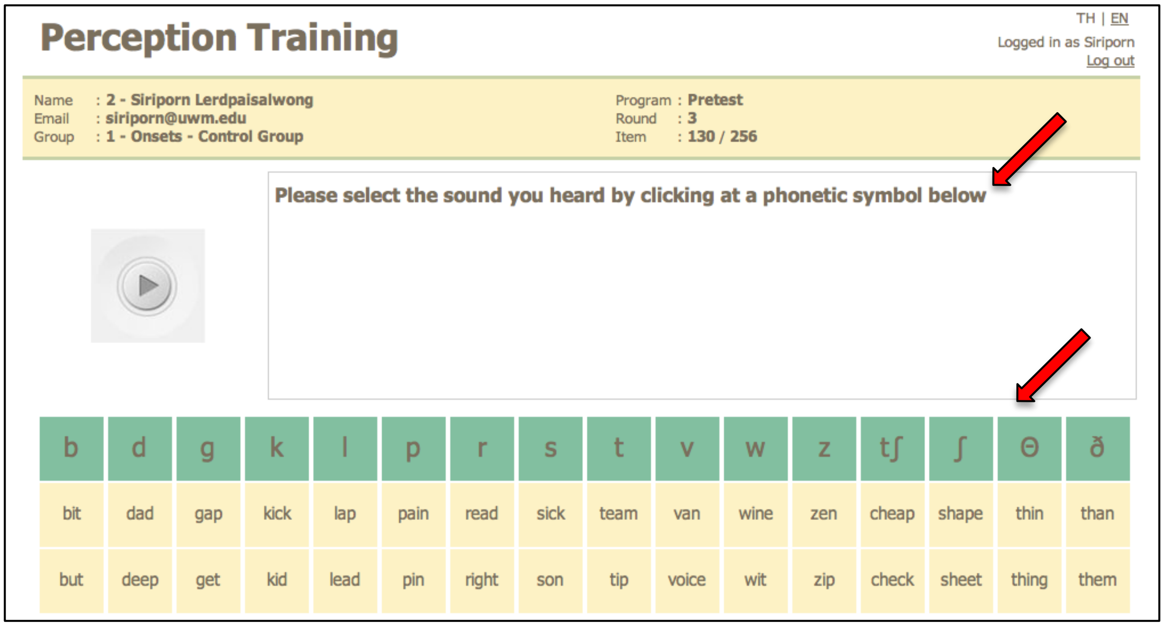


Figure 3-8: Pretest and Posttest Task Interface Step 4

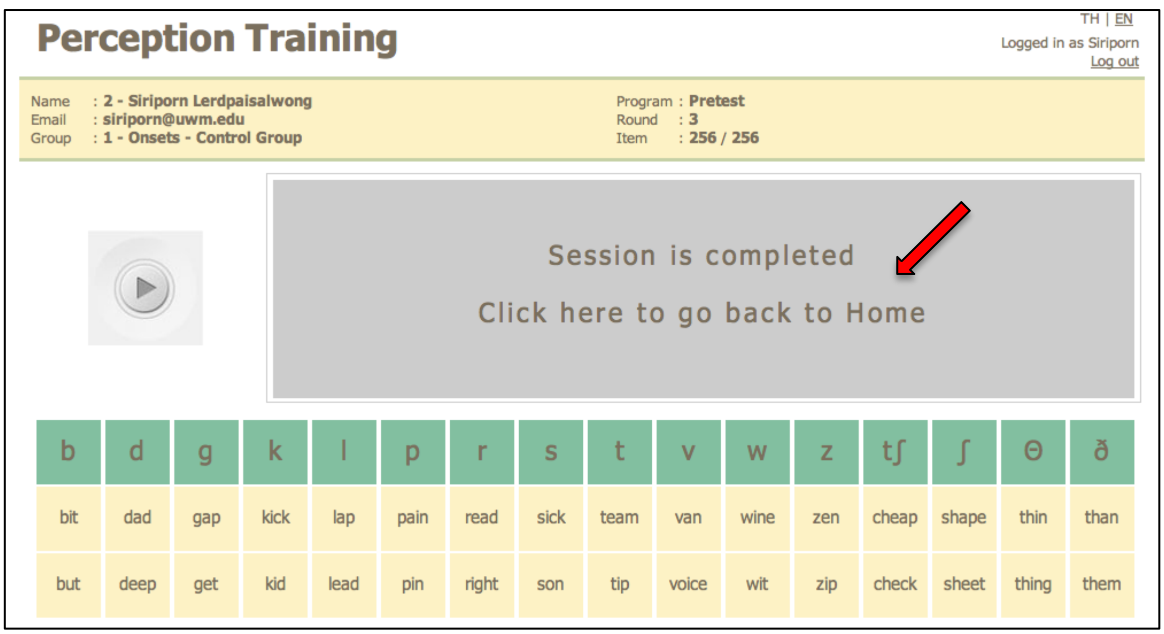


Figure 3-9: Pretest and Posttest Task Interface Step 5

3.4 **Training** (Adapted from Nishi & Kewley-Port, 2007)

The listeners in the six training groups went through seven days of training sessions between the pre- and posttests. The length of training sessions is different from one group to another, because the number of trials in each training group is different from one group to another. A single session lasted an average of 25 minutes. For the vowel fullset group, each session consisted of four blocks of 54 trials. For the vowel subset group, each session consisted of four blocks of 18 trials. For both the onset and coda fullset groups, each session consisted of four blocks of 64 trials. For the onset subset group, each session consisted of four blocks of 16 trails. For the coda subset group, each session consisted of four blocks of 24 trials. Table 3-2 is the summary of the number of stimuli used in the six training groups (i.e., Vowel Fullset, Vowel Subset, Onset Fullset, Onset Subset, Coda Fullset, and Coda Subset).

Training Groups	Number of Word for Each Segment x Number of Segment x Number of Speaker x Number of Repetition (4 blocks) = Total Number of Stimuli
Vowel Fullset	6 consonantal contexts x 9 vowels (54 trials) x 2 speakers x 2 repetitions (4 blocks) = 216 stimuli
Vowel Subset	6 consonantal contexts x 3 vowels (18 trials) x 2 speakers x 2 repetitions (4 blocks) = 72 stimuli
Onset Fullset	4 nonsense words x 16 onsets (64 trials) x 2 speakers x 2 repetitions (4 blocks) = 256 stimuli
Onset Subset	4 nonsense words x 4 onsets (16 trails) x 2 speakers x 2 repetitions (4 blocks) = 64 stimuli
Coda Fullset	4 nonsense words x 16 codas (64 trials) x 2 speakers x 2 repetitions (4 blocks) = 256 stimuli
Coda Subset	4 nonsense words x 6 codas (24 trials) x 2 speakers x 2 repetitions (4 blocks) = 96 stimuli

Table 3-2: The Summary of the Number of Stimuli Used in Each Training Group

The six following tables show details of the stimuli used in the six training groups.

Vowel Fullset: 6 consonantal contexts x 9 vowels x 2 speakers x 2 repetitions = 216

9 Vowels	6 Consonantal Contexts
i	beeba /bibə/, beepa /bipə/, deeda /didə/, deeta /ditə/, geega /gigə/, geeka /gikə/
ɪ	biba /bɪbə/, bipa /bɪpə/, dida /dɪdə/, dita /dɪtə/, giga /gɪgə/, gika /gɪkə/
u	bouba /bubə/, boupa /bupə/, douda /dudə/, douta /dutə/, gouga /gugə/, gouka /gukə/
ʊ	booba /bʊbə/, boopa /bʊpə/, dooda /dʊdə/, doota /dʊtə/, googa /gʊgə/, gooka /gʊkə/
ɛ	beba /bɛbə/, bepa /bɛpə/, deda /dɛdə/, deta /dɛtə/, gega /gɛgə/, geka /gɛkə/
ɑ	boba /bɑbə/, bopa /bɑpə/, doda /dɑdə/, dota /dɑtə/, goga /gɑgə/, goka /gɑkə/
ʌ	buba /bʌbə/, bupa /bʌpə/, duda /dʌdə/, duta /dʌtə/, guga /dʌgə/, guka /gʌkə/
æ	baba /bæbə/, bapa /bæpə/, dada /dædə/, data /dætə/, gaga /gægə/, gaka /gækə/
ɔ	bauba /bɔbə/, baupa /bɔpə/, dauda /dɔdə/, dauta /dɔtə/, gauga /gɔgə/, gauka /gɔkə/

Table 3-3: Vowel-segment Stimuli for Fullset Perception Training

Vowel Subset: 6 consonantal contexts x 3 vowels x 2 speakers x 2 repetitions = 72

3 Vowels	6 Consonantal Contexts
ɑ	boba /bɑbə/, bopa /bɑpə/, doda /dɑdə/, dota /dɑtə/, goga /gɑgə/, goka /gɑkə/
ʌ	buba /bʌbə/, bupa /bʌpə/, duda /dʌdə/, duta /dʌtə/, guga /dʌgə/, guka /gʌkə/
ɔ	bauba /bɔbə/, baupa /bɔpə/, dauda /dɔdə/, dauta /dɔtə/, gauga /gɔgə/, gauka /gɔkə/

Table 3-4: Vowel-segment Stimuli for Subset Perception Training

Onset Fullset: 4 nonsense words x 16 onsets x 2 speakers x 2 repetitions = 256

16 Onsets	4 Nonsense Words
ð	thum /ðʊm/, thene /ði:n/, thes /ðɛs/, thoat /ðoʊt/
d	dipe /dɑɪp/, doak /doʊk/, dum /dʊm/, dos /dɔs/
θ	thak /θæk/, thout /θɑʊt/, thoos /θus/, thoap /θoʊp/
t	tun /tʰʊn/, touk /tʰɑʊk/, toik /tʰɔɪk/, teep /tʰi:p/
v	vak /væk/, vop /vɔp/, vem /vɛm/, vees /vi:s/
w	wam /wæm/, wout /wɑʊt/, woam /woʊm/, wung /wʊŋ/
r	ren /ɹɛn/, reen /ɹi:n/, roit /ɹɔɪt/, roon /ɹun/
l	lat /læt/, lep /lɛp/, lin /lɪn/, lun /lʊn/
z	zan /zæn/, zawn /zɔ:n/, zem /zɛm/, zoat /zoʊt/
s	saip /seɪp/, seef /sif/, soit /sɔɪt/, soong /sʊŋ/
tʃ	chim /tʃɪm/, chet /tʃɛt/, choam /tʃoʊm/, choit /tʃɔɪt/
ʃ	shait /ʃeɪt/, shap /ʃæp/, shem /ʃɛm/, shoon /ʃun/
b	bim /bɪm/, bain /beɪn/, bep /bɛp/, boak /boʊk/
p	paip /pʰeɪp/, pem /pʰɛm/, peem /pʰim/, pok /pʰɔk/
g	geet /git/, gom /gɔm/, gep /gɛp/, goam /goʊm/
k	ket /kʰɛt/, koom /kʰum/, keef /kʰif/, koos /kʰus/

Table 3-5: Onset-segment Stimuli for Fullset Perception Training

Onset Subset: 4 nonsense words x 4 onsets x 2 speakers x 2 repetitions = 64

4 Onsets	4 Nonsense Words
ð	thum /ðʊm/, thene /ði:n/, thes /ðɛs/, thoat /ðoʊt/
θ	thak /θæk/, thout /θɑʊt/, thoos /θus/, thoap /θoʊp/
v	vak /væk/, vop /vɔp/, vem /vɛm/, vees /vi:s/
ʃ	shait /ʃeɪt/, shap /ʃæp/, shem /ʃɛm/, shoon /ʃun/

Table 3-6: Onset-segment Stimuli for Subset Perception Training

Coda Fullset: 4 nonsense words x 16 codas x 2 speakers x 2 repetitions = 256

16 Codas	4 Nonsense Words
ð	nithe /nɪð/, loothe /luð/, mothe /moʊð/, pathe /pæð/
d	nad /næd/, pood /pud/, keed /ki:d/, ked /kɛd/
θ	paith /peɪθ/, nath /næθ/, soath /soʊθ/, teth /tɛθ/
t	doit /dɔɪt/, dat /dæt/, ket /kɛt/, nout /nɑʊt/
v	bav /bɑv/, dov /dɔv/, kav /kæv/, poov /puv/
f	kef /kɛf/, laif /leɪf/, nof /nɔf/, paff /pæf/
r	jor /jɔɹ/, kir /k^{h}iɹ/, nar /nɑɹ/, sair /sæɹ/
l	pell /pɛl/, kail /keɪl/, noll /nɔl/, sool /sul/
z	lazz /læz/, maiz /meɪz/, paz /pɑz/, pez /pɛz/
s	boose /bus/, dass /dæs/, foos /fus/, foas /foʊs/
tʃ	boich /bɔɪtʃ/, datch /dætʃ/, metch /mɛtʃ/, toach /toʊtʃ/
ʃ	poosh /puʃ/, kash /kɑʃ/, moish /mɔɪʃ/, taish /teɪʃ/
b	doob /dub/, moob /mub/, teb /tɛb/, seeb /sib/
p	dop /dɔp/, joap /joʊp/, mep /mɛp/, koop /kup/
g	daig /deɪg/, meeg /mi:g/, soog /sug/, teeg /ti:g/
k	dak /dæk/, fook /fuk/, moak /moʊk/, tek /tɛk/

Table 3-7: Coda-segment Stimuli for Fullset Perception Training

Coda Subset: 4 nonsense words x 6 codas x 2 speakers x 2 repetitions = 96

6 Codas	4 Nonsense Words
ð	nithe /nɪð/, loothe /luð/, mothe /moʊð/, pathe /pæð/
θ	paith /peɪθ/, nath /næθ/, soath /soʊθ/, teth /tεθ/
z	lazz /læz/, maiz /meɪz/, paz /pɑz/, pez /pεz/
ʃ	poosh /puʃ/, kash /kɑʃ/, moish /mɔɪʃ/, taish /teɪʃ/
b	doob /dub/, moob /mub/, teb /tεb/, seeb /sib/
g	daig /deɪg/, meeg /mi:g/, soog /sug/, teeg /ti:g/

Table 3-8: Coda-segment Stimuli for Subset Perception Training

Among the 4 blocks, tokens produced by a female speaker (i.e., F1 [Speaker 1] for onsets and codas and F2 [Speaker 4] for vowels) were presented in two blocks, and the other two blocks contained the tokens produced by a male speaker (i.e., M2 [Speaker 3] for onsets and codas and M4 [Speaker 6] for vowels). Half of the listeners began the training with the female speaker, and the other half began the training with the male speaker.

The procedure for the training is similar to the identification task in perception pretest and posttest, except that interactive feedbacks was provided for each trial. When a listener identified a target segment correctly, a sub-window appeared on the screen with the feedback text “Correct” and two response buttons for listening to the correct sound and for moving to the next trial (see Figure 3-10).

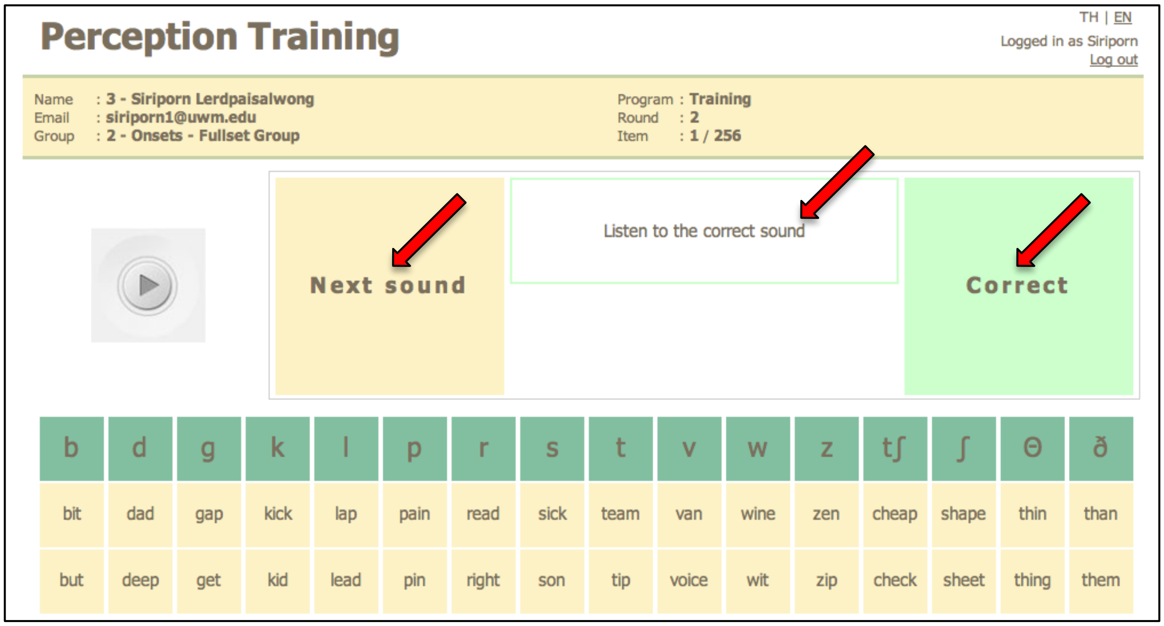


Figure 3-10: Training Task Interface with the Correct Target Segment

When the answer was wrong, a sub-window appeared on the screen with the feedback text "Incorrect" and three response buttons for listening to the correct sound, for listening to the incorrect sound s/he just heard, and for moving to the next trial (see Figure 3-11).

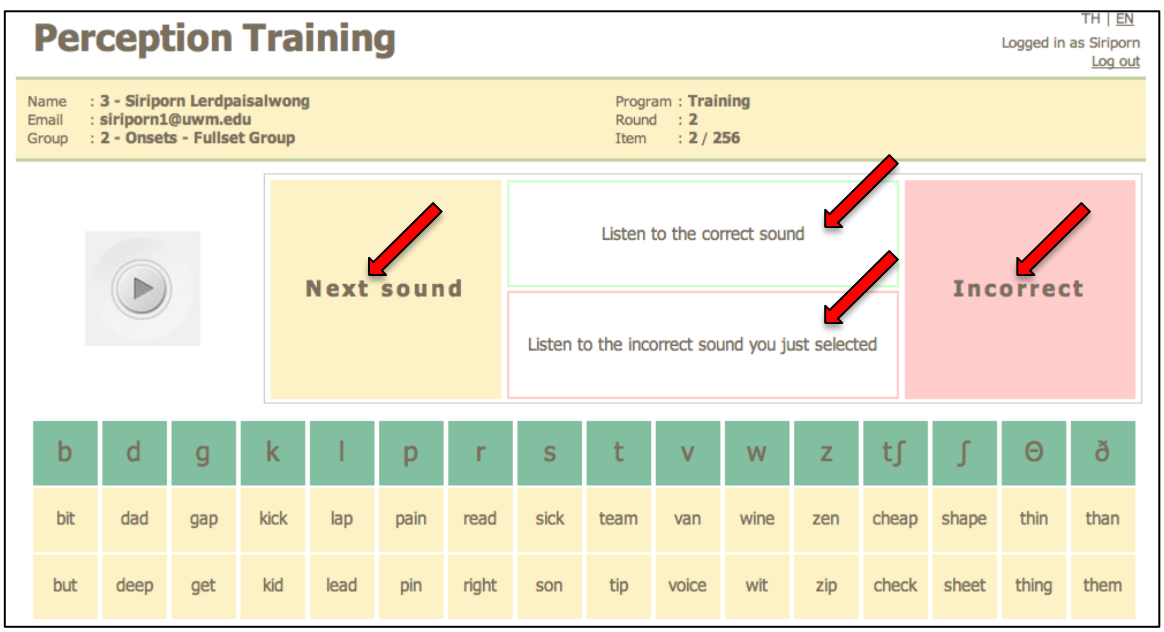


Figure 3-11: Training Task Interface with the Incorrect Target Segment

The listener was then presented the sound of the correct answer (stimulus) and the incorrect answer (randomly chosen from the four words in any combination), with an option to proceed to the next trial at any time. Listeners were also able to choose to skip the feedback function by clicking on “Next Sound” to proceed to the next trial. Listeners completed all sessions, including pre- and posttest, within 6 weeks. The listeners in the control group did not receive any training.

4. Data Analysis

Section 2 of Chapter 4 presents the results of listeners in different groups to examine whether each training was effective. A paired-sample t-test was used to compare the pretest and the posttest scores of each group. This allows us to determine whether trainees made a significant improvement in their perception abilities after the trainings. By comparing the t-test results, the type of training that was the most effective (i.e., Fullset vs. Subset) was also investigated.

A two-way mixed-design ANOVA was performed to see whether there were any changes over time (e.g., from Time one [the perception pretest] to Time two [the perception posttest]) across the three different groups (i.e., fullset, subset, and control); and to see whether there were any significant differences between those groups in the posttests. When the mixed-design ANOVA yielded significant results, a Bonferroni post-hoc test was conducted to see which group between the three different groups[5] (i.e., fullset, subset, and control) differed significantly from one another.

A one-way ANOVA was used to investigate which group between the three different groups (i.e., fullset, subset, and control) improved listeners' perception abilities the most by the posttest or provided the most effective perception training. When the one-way ANOVA drew significant results, a post-hoc test (Tukey HSD) was used to see which group between the three different groups (i.e., fullset, subset, and control) differed significantly from one another.

Section 3 of Chapter 4 presents the improvements of *listener's* difficult and easy segments in both vowel and consonant groups (i.e., vowel, onset, and coda) and in two different types of techniques (i.e., Fullset and Subset). An independent t-test was used to test whether the perception abilities of difficult and easy segments in the pretest of each group (i.e., vowel fullset, vowel subset, onset fullset, onset subset, coda fullset, and coda subset) were significantly different or not. By doing so, I attempted to confirm that the participants in all six groups were at the same level of listening proficiency before the perception training. The independent t-test was also used to examine whether the perception abilities of difficult and easy segments in the posttests are significantly different or not. I then explored which technique is the most effective in training vowel and consonants, respectively, as well as in training different groups of segments (i.e., difficult and easy).

[5] The phrase "between the three different groups" is used here rather "among the three different groups", since the pairwise comparisons were done with each pair respectively (e.g., Vowel Fullset vs. Vowel Subset and Vowel Fullset vs. Vowel Control).

Section 4 of Chapter 4 presents the improvements of difficult and easy segments in both vowel and consonant groups (i.e., vowels, onsets, and codas) and in two different types of techniques (i.e., Fullset and Subset). A paired-sample t-test was used to test whether the perception abilities of both difficult and easy segments in the posttests are significantly different from their perception abilities in the pretest. This was to show which technique is the most effective in training vowel and consonants, respectively, as well as in training different groups of segments (i.e., difficult and easy segments).

Section 5 of Chapter 4 reports the results on the generalization to a new talker. A two-way mixed-design ANOVA was conducted to see whether there are any changes over time (i.e., from Time one [the perception pretest] to Time two [the perception posttest]) across two different talkers (i.e., between speakers 2 and 3, and between speakers 5 and 6); and to see whether there are any significant differences between groups (i.e., between the group of speakers 2 and 3 and the group of speakers 5 and 6). A paired-sample t-test was also used to see whether there are any significant differences between the results of the perception abilities for the tokens produced by two different speakers in the training session and in the posttests (i.e., comparing speakers 3 and 6 from the training sessions with speakers 2 and 5 from the posttests, respectively) in vowel and consonants, respectively, as well as in training different groups of segments (i.e., difficult and easy). By doing so, the generalization of the perception abilities from one talker to a new talker can be tested. To illustrate, the test was conducted to examine whether L1 Thai learners of L2 English could generalize or not their perception abilities, originally trained by tokens produced by speakers 3 and 6, to the new speakers 2 and 5 in the posttest.

Chapter 4

Results

1. Introduction

The previous chapter showed the details of two perception training techniques (i.e., Fullset and Subset) used to train onset consonants, coda consonants, and vowels. In this chapter, the results from the six training groups (i.e., Vowel Fullset, Vowel Subset, Onset Fullset, Onset Subset, Coda Fullset, and Coda Subset) are presented. First, the results of listeners in each group are presented in order to see whether each of those training groups is effective or not. I also examined which type of training is the most effective (i.e., Fullset vs. Subset) for training the vowel, the onset, and the coda, respectively, in order to answer the first and the second questions of this study. Second, the improvement of Thai listeners in the six training groups is presented comparing easy and difficult segments. Third, the improvement of each segment trained in those groups is presented again to see the interaction between the different types of training (i.e., fullset vs. subset) and the different types of segments (i.e., difficult vs. easy). The detailed analyses of difficult and easy segments from the six training groups are also presented. Fourth, the generalization to different talkers of the trained segments in the six training groups is presented. The last three topics answer the third and the fourth questions of this study.

2. Fullset vs. Subset
2.1 Vowel Fullset vs. Vowel Subset vs. Vowel Control

Figure 4-1 presents the improvement of the listeners from the vowel perception training groups after the training. The three groups - vowel fullset, vowel subset, and vowel control - are placed right next to each other on the x-axis. The percentage of correctness of the perception pretest and posttest is on the y-axis. The black bars represent the perception pretest scores and the white bars represent the perception posttest scores.

A series of a paired-sample t-test were conducted to see whether the pre- and posttest scores were significantly different from each other, or whether the training was effective for the trained groups. The results indicated that after the training, the vowel fullset group listeners' scores improved significantly [$t(8) = -7.362$, ($p < .01$, two-tailed)]. Figure 4-1 also shows that the first white bar is much higher than the first black bar for the vowel fullset group. The scores of the vowel subset group listeners also improved significantly [$t(9) = -2.714$ ($p < .05$, two-tailed)] and this is also shown in Figure 4-1: the second white bar is higher than the second black bar. The scores of the vowel control group listeners were not significantly different from each other when their pre- and posttest scores were compared, according to the paired-sample t-test.

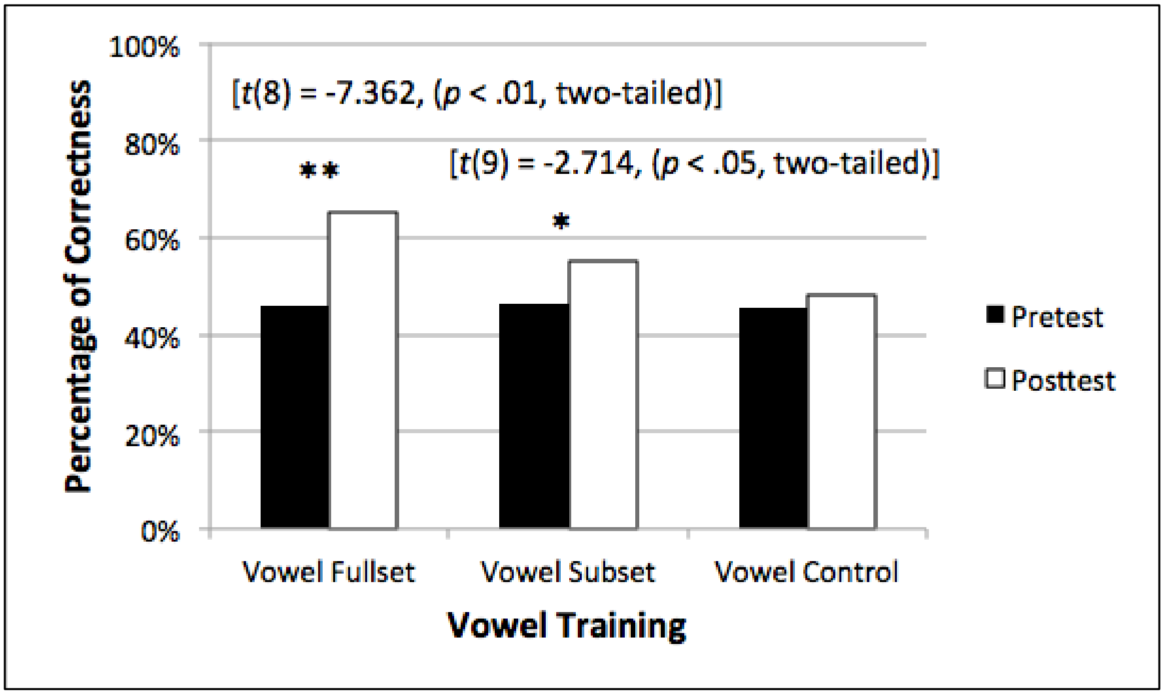


Figure 4-1: The Comparison of Pretest and Posttest Perception among Vowel Fullset, Vowel Subset, and Vowel Control groups

The improvement difference between groups was analyzed in a two-way mixed-design ANOVA, with *time* (pretest and posttest) as a within-subjects factor and *groups* (Vowel Fullset, Vowel Subset, and Vowel Control) as a between-subject factor. There was a main effect of *time*, $F(1, 29) = 33.818$, $p < .01$, indicating that there were changes over time in the perception scores from the pretest to posttest periods across the three different groups (i.e., vowel fullset, vowel subset, and vowel control). However, there was no main effect of *groups*, $F(2, 29) = 2.399$, $p > .05$, indicating that the groups' average scores across the pre- and posttests did not differ from one another. More importantly, there was a significant interaction between *time* and *groups,* $F(2, 29) = 7.421$, $p < .01$. This indicates that the changes of the perception scores over time from pretest to posttest were not equivalent across the three groups.

Follow-up *post hoc* test using Bonferroni revealed that the listeners' scores between groups were not significantly different at the pretest period. However, at the posttest period, the fullset group's scores were significantly higher than the control group's ($p < .01$), while the subset group's scores were not significantly higher than the control group's ($p > .05$). Although the fullset group's scores were considerably higher than the subset group's scores, the difference was not statistically significant at the .05 level. In sum, there was no significant difference between groups in the pretest scores and the control group's scores did not change over time. However, the trained groups (i.e., vowel fullset and vowel subset) showed some improvement in their perception of vowels over time and the vowel fullset group showed more improvement.

2.2 Onset Fullset vs. Onset Subset vs. Onset Control

Figure 4-2 presents the improvement of the listeners from the onset perception training groups after the trainings. The three groups - onset fullset, onset subset, and onset control - are placed right next to each other on the x-axis. The percentage of correctness of the perception pretest and posttest is on the y-axis. The black bars represent the perception pretest scores and the white bars represent the perception posttest scores.

A series of paired-sample t-tests were conducted to see whether the pre- and the post-test scores were significantly different from each other, or the training was effective for the participating groups. The results indicated that after the training, the onset fullset group listeners' scores improved significantly [$t(9)$ =

-6.117, ($p < .01$, two-tailed)]. Figure 4-2 also shows that the first white bar is much higher than the first black bar for the onset fullset group. The scores of the onset subset group listeners also improved significantly [$t(9) = -2.191$ ($p < .05$, two-tailed)] and this is also shown in Figure 4-2: the second white bar is higher than the second black bar. The scores of the onset control group listeners were not significantly different from each other when the pre- and posttest scores were compared.

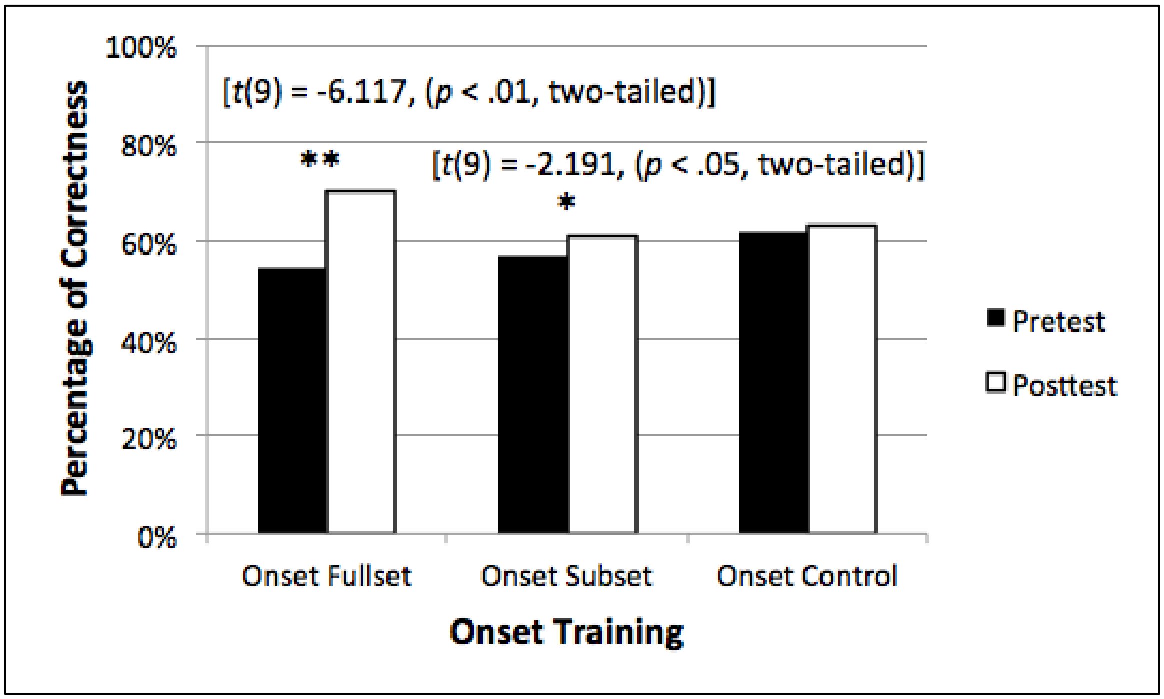


Figure 4-2: The Comparison of Pretest and Posttest Perception among Onset Fullset, Onset Subset, and Onset Control groups

The improvement difference between groups was analyzed in a two-way mixed-design ANOVA, with *time* (pretest and posttest) as a within-subjects factor and *groups* (Onset Fullset, Onset Subset, and Onset Control) as a between-subjects factor. There was a main effect of *time*, $F(1, 28) = 36.838$, $p < .01$, indicating that there were changes over time in perception scores from pretest to posttest periods across the three different groups (i.e., onset fullset, onset subset, and onset control). However, there was no effect of *groups*, $F(2, 28) = .774$, $p > .05$, indicating that the groups' average scores across pre- and posttests did not differ from one another. More importantly, there was a significant interaction between *time* and *groups*, $F(2, 28) = 14.463$ $p < .01$. This indicates that the changes of perception scores over time from pretest to posttest were not equivalent across the three groups.

Follow-up *post hoc* test using Bonferroni revealed that the listeners' scores between groups were not significantly different at the pretest period. However, at the posttest period the fullset group's scores were significantly higher than the subset group's ($p < .05$), although the fullset group's scores were not significantly higher than the control groups' ($p > .05$). The subset group's scores were not significantly higher than those of the control groups either ($p > .05$). In sum, there was no significant difference between groups in the pretest scores and the control group's scores did not change over time. Nonetheless, the trained groups (i.e., onset fullset and onset subset) showed some improvement in their perception of onsets over time and the onset fullset group showed even more improvement.

To confirm whether the improvement of the onset fullset group was more than that of the onset subset group, a one-way ANOVA was conducted with *groups* (onset fullset, onset subset, and onset control) as a between-subjects factor and *difference score* as a dependent variable. The *difference score* was obtained by subtracting pretest scores from posttest scores in each group. These difference scores were to show how much trained groups improved as a result of the training. The ANOVA analysis showed the main effect of *groups*, $F(2,30) = 14.463$, $p < .01$. Thus, I conducted a *post-hoc* test (Tukey HSD) to see the further differenes in improvements between the three groups. The results indicate that the onset fullset group's improvement was significantly higher than the other two groups' improvement ($p < .01$). However, the onset subset's improvement was not significantly higher than those of the onset control group at the .05 level.

2.3 Coda Fullset vs. Coda Subset vs. Coda Control

Figure 4-3 presents the improvement of the listeners form the coda perception training groups after the trainings. The three groups - coda fullset, coda subset, and coda control - are placed right next to each other on the x-axis. The percentage of correctness of perception pretest and posttest is on the y-axis. The black bars represent the perception pretest scores and the white bars represent the perception posttest scores.

A series of a paired-sample t-test were conducted to see whether pre- and posttest scores were significantly different form each other, or the training was effective for the participating groups. The results indicated that after the training, the coda fullset group listeners' scores improved significantly [$t(8) = -7.377$, ($p < .01$, two-tailed)]. Figure 4-3 also shows that the first white bar is much higher than the first black bar for the coda fullset group. The scores of the coda subset group listeners also improved significantly [$t(9) = -4.231$ ($p < .01$, two-tailed)] and this is shown in Figure 4-3: the second white bar is considerably higher than the second black bar. The scores of the coda control group listeners were not significantly different from each other when pre- and posttest scores were compared, according to the paired-sample t-test.

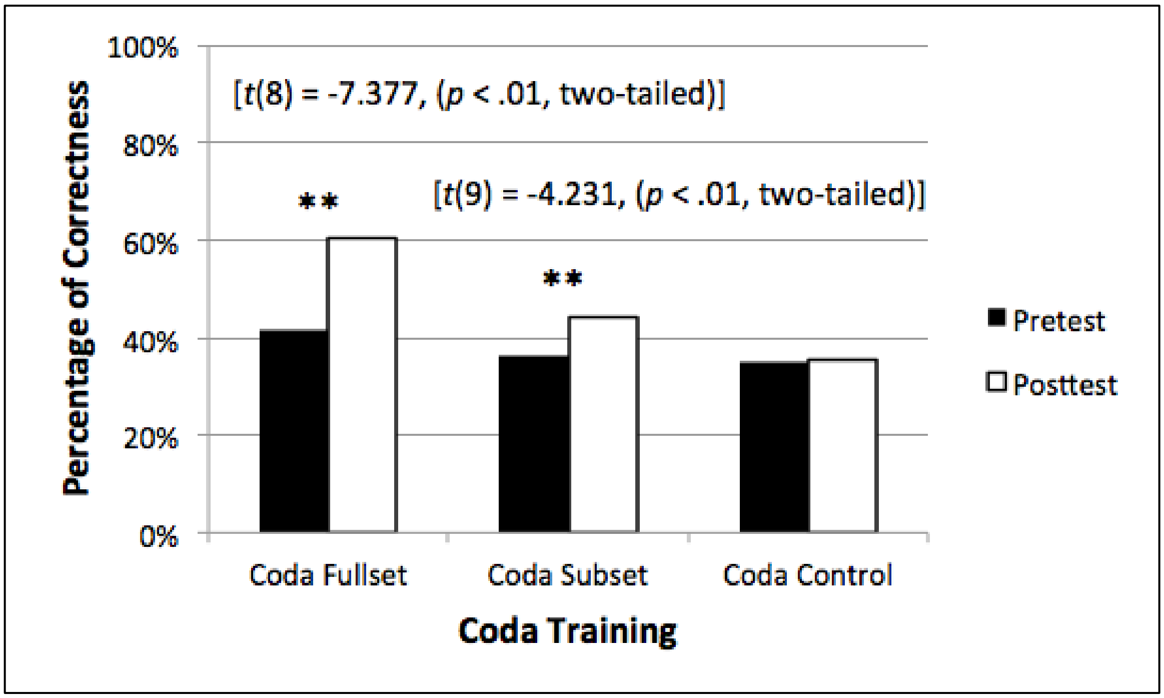


Figure 4-3: The Comparison of the Pretest and the Posttest Perception among Coda Fullset, Coda Subset, and Coda Control groups

The improvement difference between groups was analyzed in a two-way mixed-design ANOVA with *time* (pretest and posttest) as a within-subjects factor and *groups* (Coda Fullset, Coda Subset, and Coda Control) as a between-subjects factor. There was a main effect of *time*, $F(1, 27) = 72.263$, $p < .01$, indicating that there were changes over time in perception scores from pretest to posttest periods across the three different groups (i.e., coda fullset, coda subset, and coda control). There also was a main effect of *group*, [$F(2, 27) = 5.984$, ($p <$

.01)], indicating that the groups' average scores across pretest and post-test differed from one another. More importantly, there was a significant interaction between *time* and *groups*, $F(2, 27) = 24.101$, $p < .01$. This indicates that the changes of the perception scores over time from pretest to posttest were not equivalent across the three groups.

Follow-up *post hoc* test using Bonferroni revealed that the listeners' scores between groups were not significantly different at the pretest period. However, at the posttest period, the fullset group scores were significantly higher than both the control group's and the subset group at the .01 level, while the subset group's scores were not significantly higher than the control group's ($p > .05$). In conclusion, there was no significant difference between groups in the pretest scores and the control group scores did not change over time. Nevertheless, the trained groups (i.e., coda fullset and coda subset) showed some improvement in their perception of codas over time and the coda fullset group showed more improvement than the coda subset group.

To confirm whether the coda fullset group was more effective than the coda subset group, a one-way ANOVA was conducted with *groups* (coda fullset, coda subset, and coda control) as a between-subjects factor and *difference score* as a dependent variable. The *difference score* was obtained by subtracting pretest scores from posttest scores within each group. These difference scores were used to show how much groups improved as a result of training. The ANOVA analysis showed the main effect of *groups*, $F(2,29) = 24.101$, $p < .01$. Thus, I conducted a *post-hoc* test (Tukey HSD) to see any further differences in improvements between the three groups. The results indicate that the coda fullset group's improvement was significantly higher than the other two groups' improvement ($p < .01$). And the coda subset group's improvement was significantly higher than those of the coda control group at the .05 level.

3. Listener Analyses

This section presents the listeners' difficult and easy segment perception scores in the pretest, training sessions, and posttest, separately. This was done because the subset group listeners (i.e., vowel subset, onset subset, and coda subset) were trained with only the difficult segments. Therefore, a separate analysis is necessary for comparing of the two training techniques (i.e., Fullset vs. Subset) in order to reveal which type of training is the most effective in training Thai EFLs with the different segments investigated (i.e., vowels, onsets, and codas). Importantly, through this analysis the individual learner's learning patterns of the two different types of segments (i.e., easy and difficult) are revealed.

3.1 The Improvement of Listener in Vowel Fullset and Vowel Subset

Figure 4-4 illustrates the vowel fullset group listeners' scores for the difficult segments (i.e., /ɑ ɔ ʌ/). The x-axis represents stages each listener went through starting from the pretest, the seven training sessions, and the posttest. The y–axis represents the scores in percentage of correctness. Each line represents each listener and the markers on the line mark each stage. This figure helps us examine individual learners' learning patterns. Figure 4-5 illustrates the vowel subset group listeners' scores for the difficult segments, and this figure is organized in the same way as Figure 4-4.

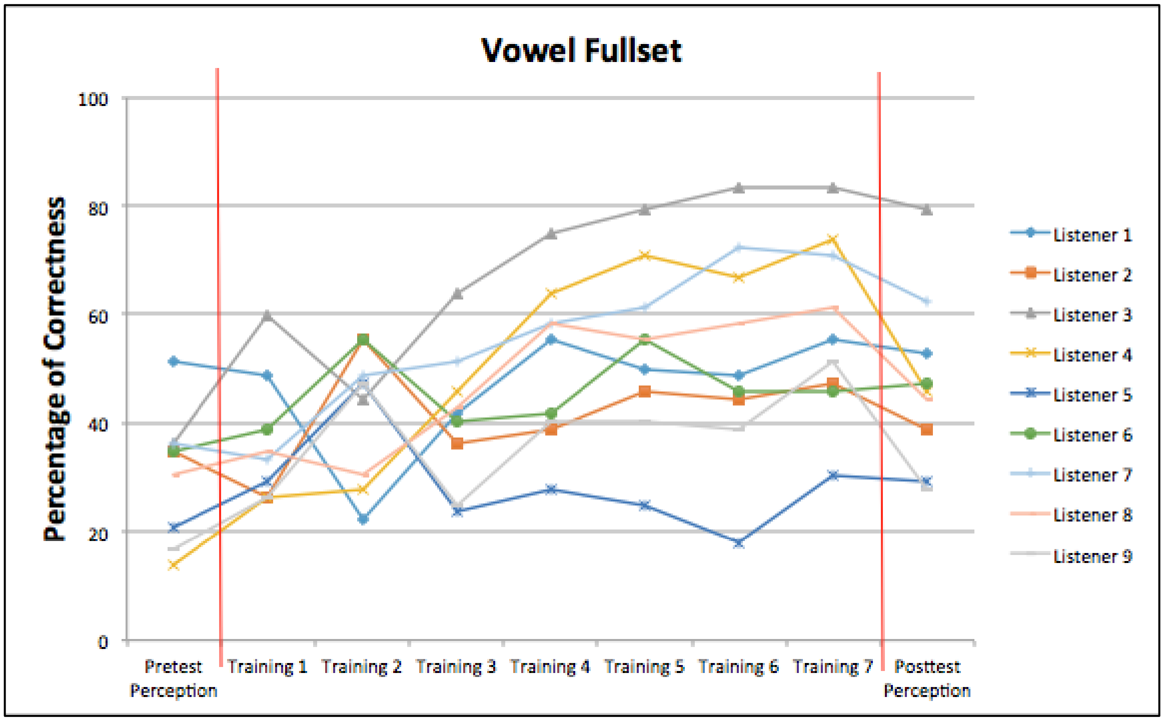


Figure 4-4: Vowel Fullset Listeners' Scores of Difficult Segments from Pretest to Posttest

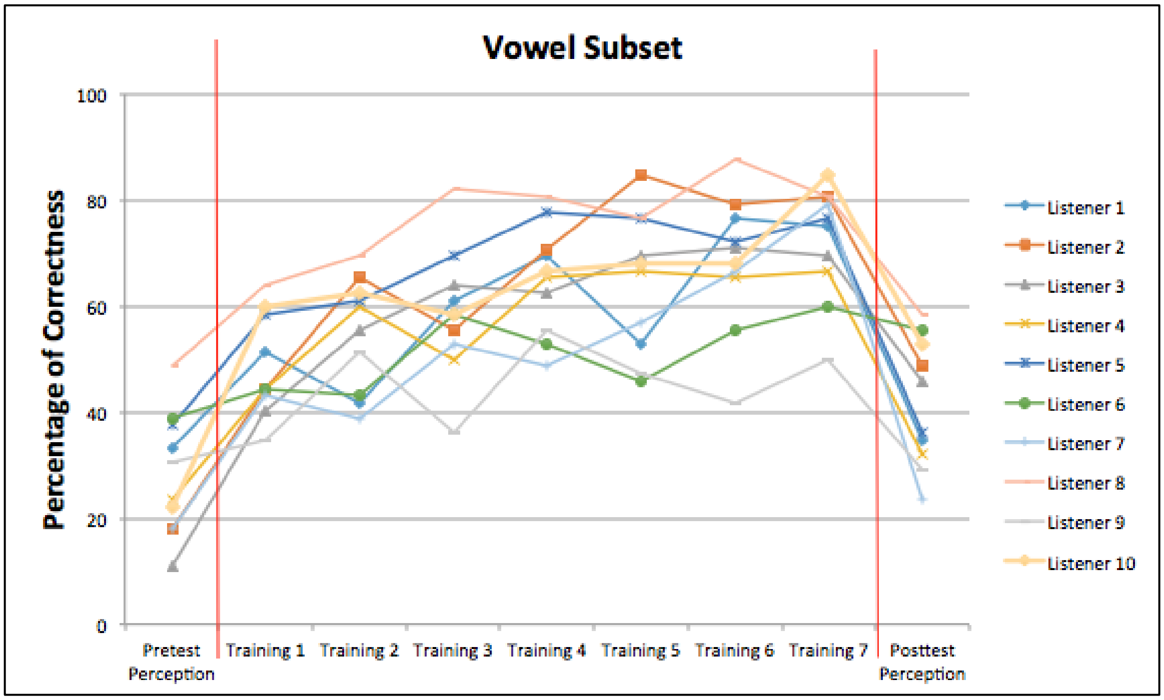


Figure 4-5: Vowel Subset Listeners' Scores of Difficult Segments from Pretest to Posttest

As we can see in Figure 4-4, the vowel fullset group listeners' difficult segment perception scores increased gradually from the first training session to the last training session. Their scores in the perception posttest decreased a little bit from their scores in the last training session. A similar pattern can be observed among the vowel subset group listeners. As shown in Figure 4-5, the listeners' difficult segment perception scores increased gradually from the first training session to the last training session and their scores in the posttest decreased considerably from their scores in the last training session. When comparing the two groups, we can see that the fullset group's performance during the seven training sessions varies more than the subset group's performance. The two groups' scores did not differ significantly from each other at the pretest, $t(17) = .828$, $p > .05$, *two-tailed*, nor at the posttest, $t(17) = .794$, p

> .05, *two-tailed*, according to an independent t-test. Nevertheless, we cannot ignore that the performance of the vowel fullset group listeners was more varied than the subset group listeners for the difficult vowels. The fullset group listeners' scores ranged from 28% to 79%, while the subset group listeners' scores ranged from 29% to 58%.

Figures 4-6 presents the fullset group listeners' scores for the easy vowels (i.e., /i ɪ ɛ æ ʊ u/), across same times as above, respectively. Figure 4-6 follows the same structure as in the previous two figures for the difficult vowels. Note that the subset group was not trained with the easy vowels. Therefore, Figure 4-7 presents only the comparison of the vowel subset group listeners' perception pretest scores and perception posttest scores, without their training scores.

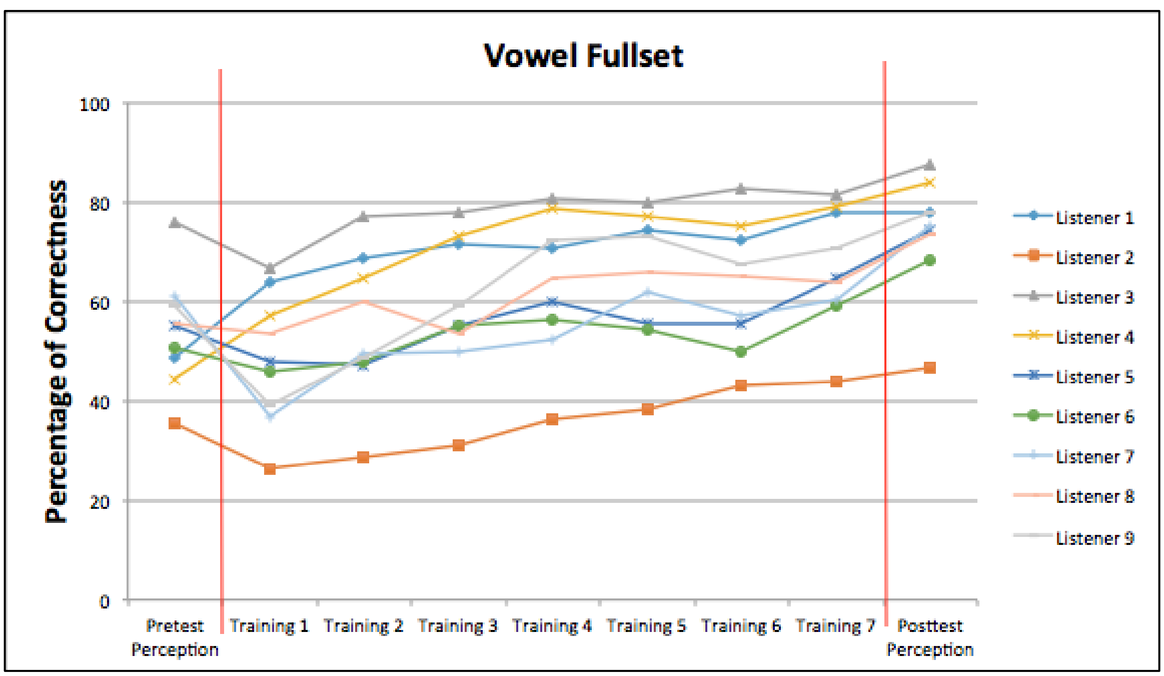
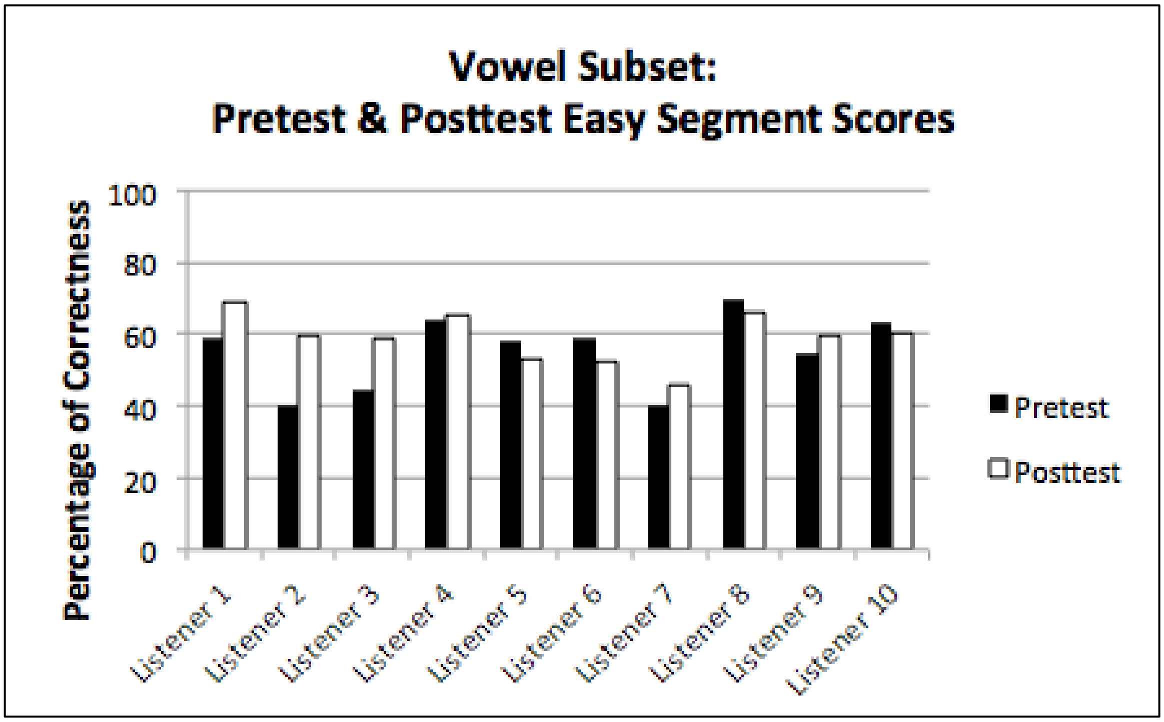


Figure 4-6: Vowel Fullset Listeners' Scores of Easy Segments from Pretest to Posttest



Figures 4-7: Vowel Subset Listeners' Scores of Easy Segments from Pretest and Posttest

Figure 4-7 shows that the vowel fullset group listeners' easy segment perception scores increased gradually from the first training session to the last training session. And, their scores in the perception posttest were a little bit better than their scores in the last training session. On the other hand, the vowel subset group listeners' easy segment posttest scores varied. For example, the scores of some listeners considerably increased (i.e., Listeners 1-3), while the scores of some listeners increased just a little bit (i.e., Listeners 4, 7, and 9). And, the scores of some listeners slightly dropped (i.e., Listeners 5, 6, 8, and 10). I, therefore, conducted an independent t-test to see whether the benefit of the fullset training could be shown for the easy vowels (e.g., the difference between the fullset group's scores and the subset group's scores at the posttest.). However, the independent t-test showed that there was no significant difference between the two groups in the posttests [$t(17) = .495$, ($p > .05$, two-tailed)]. The posttest scores of the vowel fullset group ranged from 47% to 84%, while those of the vowel subset group ranged from 46% to 69%. Neither were the scores of both groups in the perception pretests significantly different [$t(17) = -.272$ ($p > .05$, two-tailed)], although there were two listeners in the vowel fullset group whose performances deviated a little bit (i.e., 35% and 76%).

3.2 The Improvement of Listener in Onset Fullset and Onset Subset

Figure 4-8 presents the onset fullset group listeners' scores for the difficult segments (i.e., /v ð θ ʃ/). The x-axis represents stages each listener went through from the pretest, seven training sessions, and the posttest period. The y-axis represents the scores in percentage of correctness. Each line represents each listener and the markers on the line mark each stage. This figure helps us examine individual learners' learning patterns. Figure 4-9 illustrates the onset subset group listeners' scores for the difficult segments, and this figure is organized in the same way as Figure 4-8.

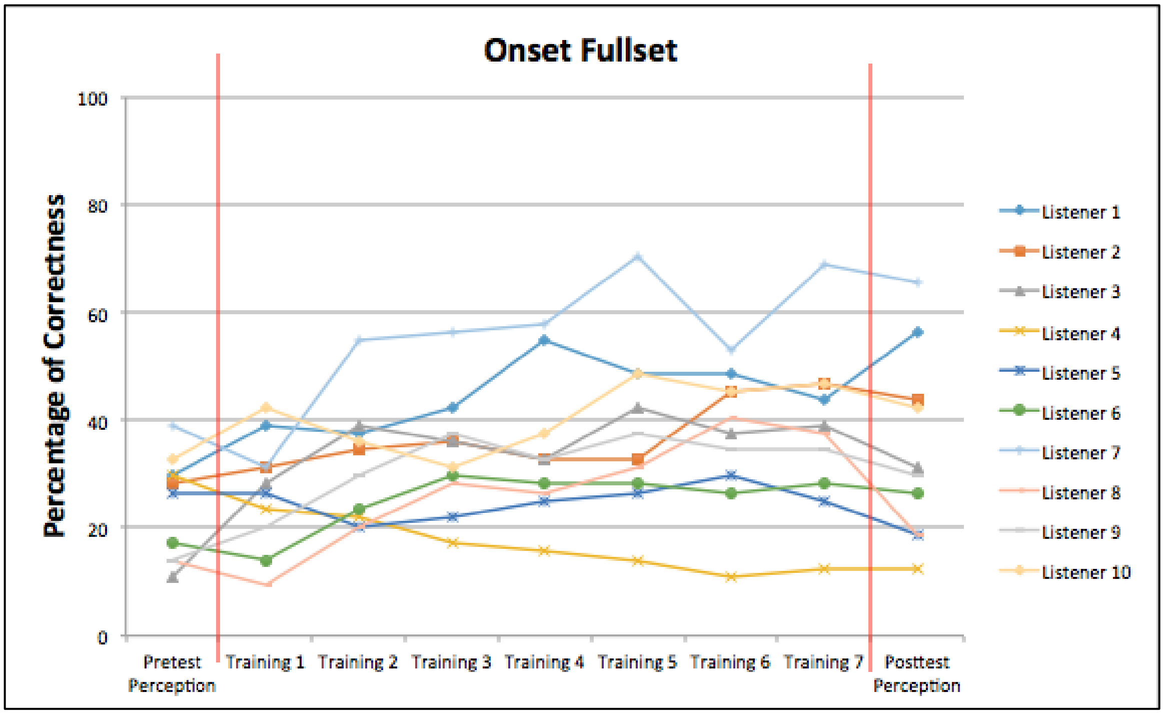


Figure 4-8: Onset Fullset Listeners' Scores of Difficult Segments from Pretest to Posttest

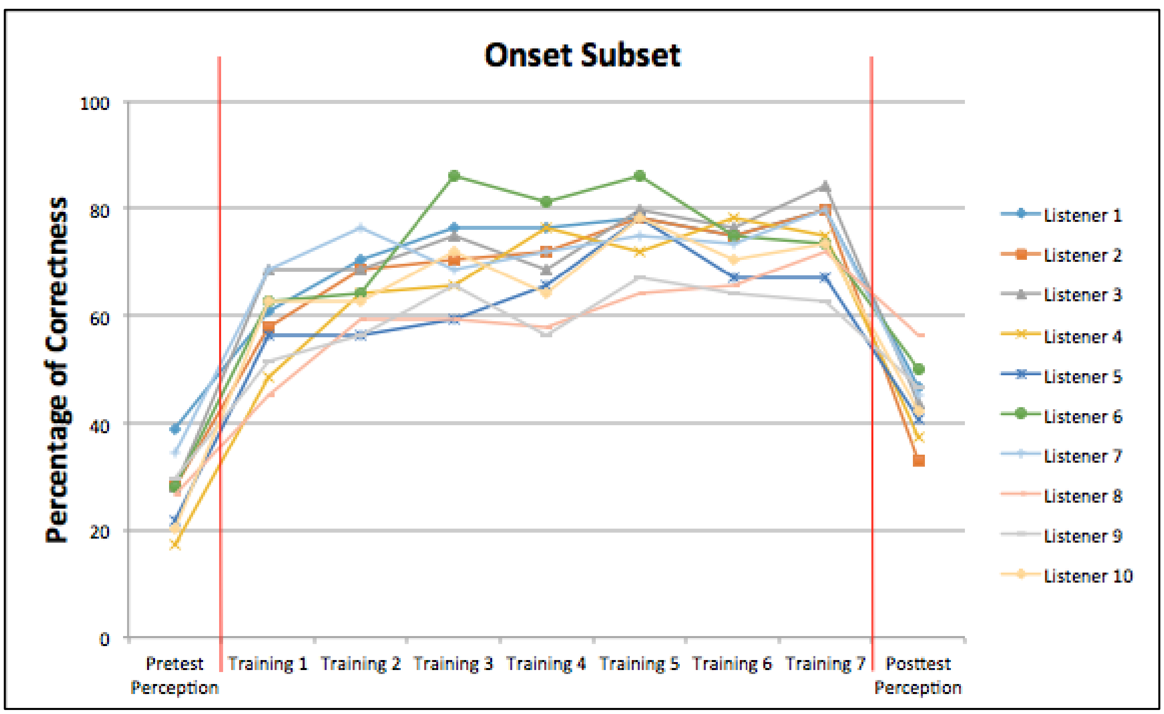


Figure 4-9: Onset Subset Listeners' Scores of Difficult Segments from Pretest to Posttest

Figure 4-8 shows that the onset fullset group listeners' difficult segment perception scores increased gradually from the first training session to the last training session, except Listener 4 whose scores decreased gradually. Also, their scores in the perception posttest decreased a little bit from their scores in the last training session, except Listener 1. Figure 4-9 also shows that the onset subset group listeners' difficult segment perception scores increased gradually from the first training session to the last training session, but increased a lot from the perception pretest to the first training session. Also, the scores of the onset subset group listeners in the perception posttest decreased considerably from their scores in the last training session. This might be because their performance at the last training session was much better than that of the fullset group. Thus, the decrease of the subset group's scores in the posttest seemed to be more drastic. When comparing the onset fullset group listeners' performance of the difficult segments with that of the onset subset group listeners, the performance of the onset fullset group listeners during the seven trainings sessions varied more than that of the onset subset group listeners, although the scores of both groups in the perception pretests looked similar, except the four onset fullset listeners whose scores were lower than 20%.

An independent t-test revealed that there was no significant difference between the difficult segment scores of the onset fullset group and those of the onset subset groups in both the pretest [$t(17) = -1.103$, ($p > .05$, two-tailed)] and the posttest [$t(18) = -1.664$, ($p > .05$, two-tailed)]. Nevertheless, in the perception posttest, the scores of the listeners in the onset fullset training group varied more than those of the listeners in the onset subset training group. The posttest scores of the onset fullset group ranged from 13% to 66%, while those of the onset subset group ranged from 33% to 56%.

Figure 4-10 presents the onset fullset group listeners' scores for the easy segments (i.e., /b p d t k g r l s z w tʃ/) across times, respectively. Figure 4-10 follows the same structure as in the previous two figures for the difficult onsets. Note that the subset group was not trained with the easy onsets. Therefore, Figure 4-11 presents only the comparison of the onset subset group listeners' perception pretest scores and perception posttest scores, without their training scores.

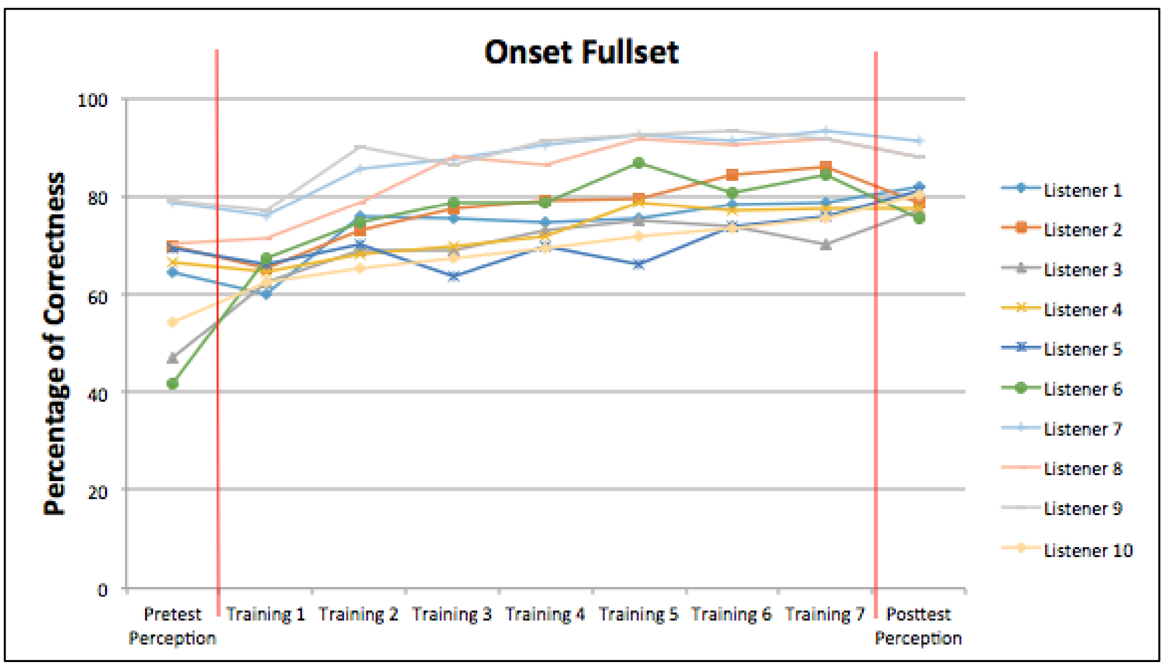


Figure 4-10: Onset Fullset Listeners' Scores of Easy Segments from Pretest to Posttest

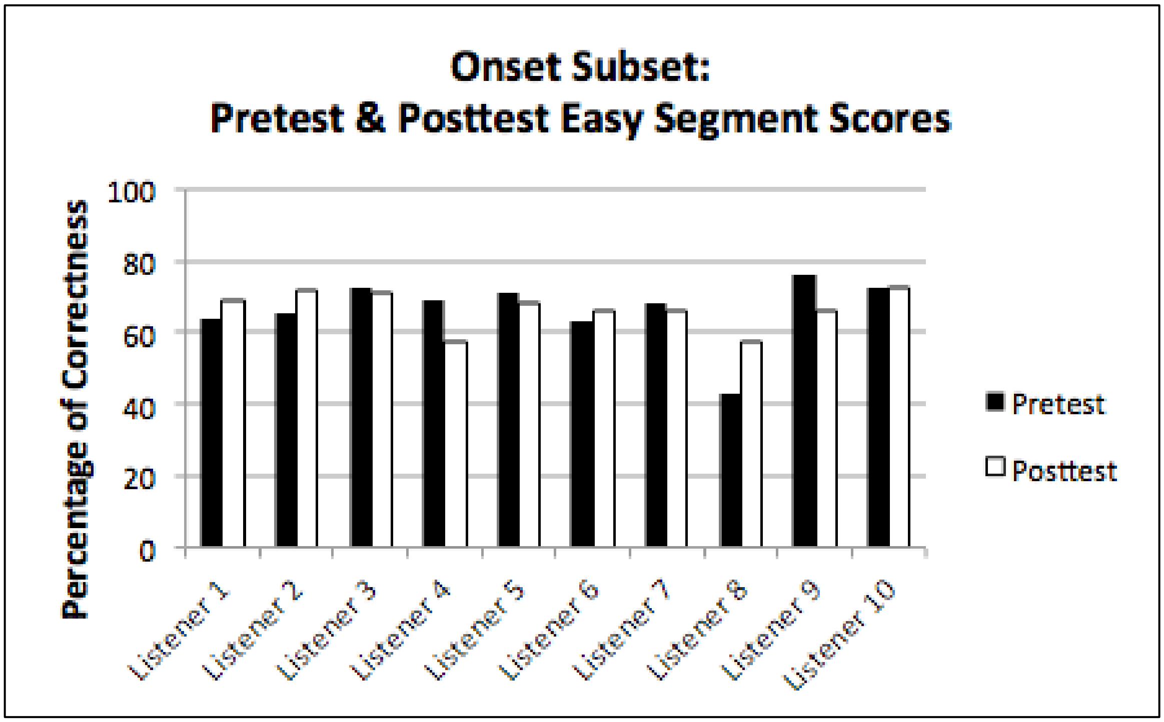


Figure 4-11: Onset Subset Listeners' Scores of Easy Segments from Pretest and Posttest

Figure 4-10 shows that the onset fullset group listeners' easy segment perception scores increased gradually from the first training session to the last training session. Also, the scores of four listeners in the perception posttest were a little bit better than their scores in the last training session, while the scores of four listeners dropped a little bit from their scores in the last training session. For Listener 1 the scores were the same as his scores in the last training session. For the onset subset group, Figure 4-11 shows that some listeners' scores increased a little bit in the posttest (i.e., Listeners 1, 2, 6, and 10), except Listener 8 whose scores increased greatly in the posttest. On the other hand, some listeners' scores slightly dropped in the posttest (i.e., Listeners 3, 5, and 7) whereas Listener 4's and 9's scores dropped sharply in the posttest. Thus, I did an independent t-test to see whether the fullset training could benefit the training of the easy onsets (e.g., the difference between the fullset group's scores and the subset group's scores at the posttest.) However, the independent t-test showed no significant difference between the two groups in the posttest [$t(18)$ = 6.369 (p > .05, two-tailed)]. The posttest scores of the fullset group ranged from 76% to 91%, while those of the subset group ranged from 57% to 73%. The scores of both groups in the perception pretests were not significantly different either [$t(19)$ = -.322 (p > .05, two-tailed)], although the scores of 2 listeners in the fullset group were lower than 50% and the scores of one listener from the subset group were lower than 50%.

3.3 The Improvement of Listener in Coda Fullset and Coda Subset

Figure 4-12 shows the coda fullset group listeners' scores for the difficult segments (i.e., /θ ð z ʃ b g/). The x-axis represents stages each listener went through starting from the pretest, the seven training sessions, and the posttest. The y-axis represents the scores in percentage of correctness. Each line represents each listener and the markers on the line mark each stage. This figure helps us examine individual learners' learning patterns. Figure 4-13 illustrates the coda subset group listeners' scores for the difficult segments, and this figure is organized in the same way as Figure 4-12.

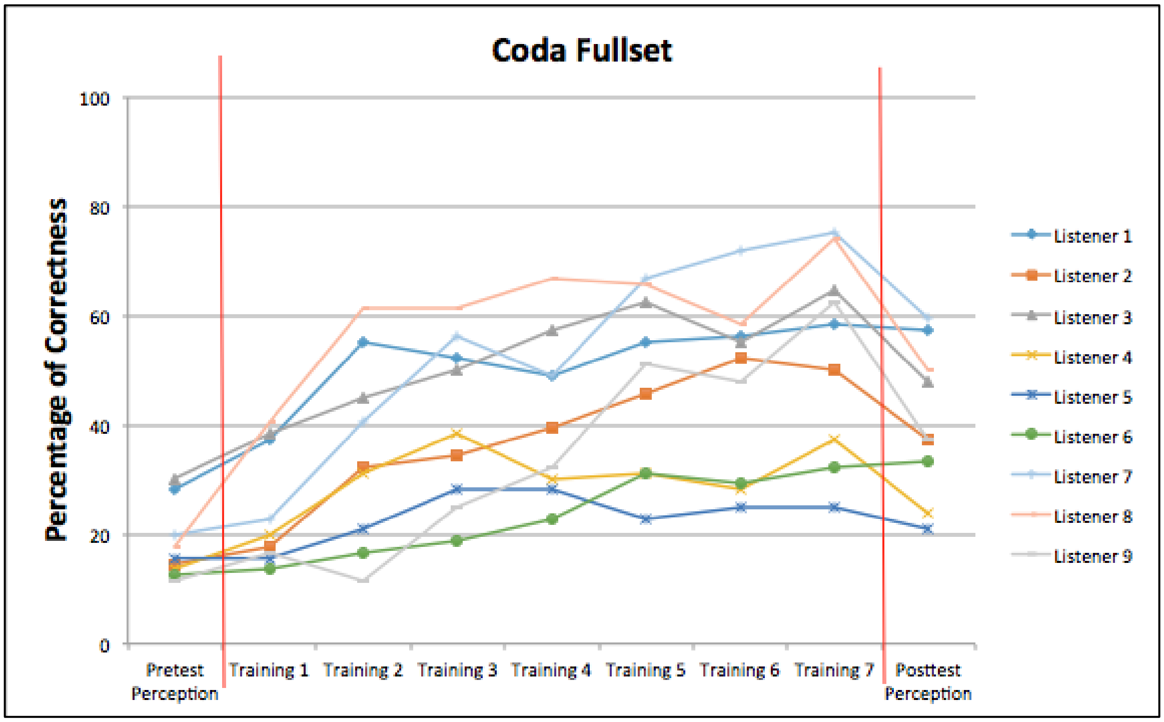


Figure 4-12: Coda Fullset Listeners' Scores of Difficult Segments from Pretest to Posttest

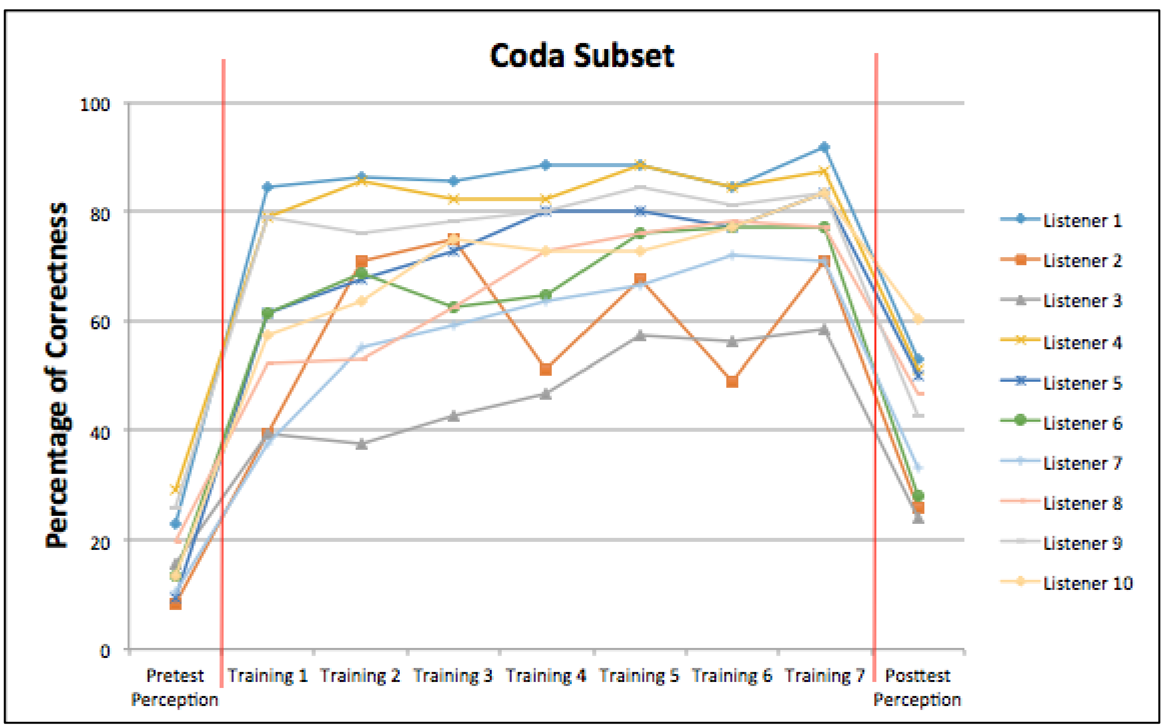


Figure 4-13: Coda Subset Listeners' Scores of Difficult Segments from Pretest to Posttest

As we can see in Figure 4-12 the difficult segment perception scores of the majority of coda fullset group listeners increased considerably from the first training session to the last training session, while the difficult segment perception scores of some listeners (i.e., Listeners 4, 5, and 6) increased gradually from the first training session to the last training session. Their scores in the perception posttest decreased quite a lot from their scores in the last training session. Figure 4-13 also shows that the coda subset group listeners' difficult segment perception scores increased gradually from the first training session to the last training session, except Listener 2 whose training scores quite fluctuated a lot and had no significant pattern. Their perception scores increased a lot from the perception pretest to the first training session, while their scores in the perception posttest decreased considerably from their scores in the last training session. The decrease of the posttest scores from the last training session of the coda subset training group was greater than that of the coda fullset training group. When comparing the coda fullset group listeners' performance of the difficult segments with that of the coda subset group listeners, the performances of listeners in both groups (i.e., fullset and subset) during the seven training sessions seemed to develop gradually. The perception pretest scores of both groups (i.e., tcoda fullset and coda subset) looked similar, and an independent t-test showed no significant difference between the difficult segment scores of both groups in the pretest [$t(17) = .621$ ($p > .05$, two-tailed)]. In the perception posttest, the difficult segment scores of the coda fullset group listeners varied more than those of the coda subset group listeners. The posttest scores of the coda fullset group ranged from 21% to 59%, while those of the coda subset group ranged from 24% to 60%. However, the independent t-test revealed no significant difference between the difficult segment scores of the coda fullset group and those of the coda subset group in the posttest [$t(17) = -.116$ ($p > .05$, two-tailed)].

Figure 4-14 presents the fullset group listeners' scores for the easy codas (i.e., /p d t k r l s v f tʃ/), across time, respectively. Figure 4-14 follows the same structure as the previous two figures for the difficult codas. Note that the subset group was not trained with the easy codas. Therefore, Figure 4-15 presents only the comparison of the subset group listeners' perception pretest scores and perception posttest scores, without their training scores.

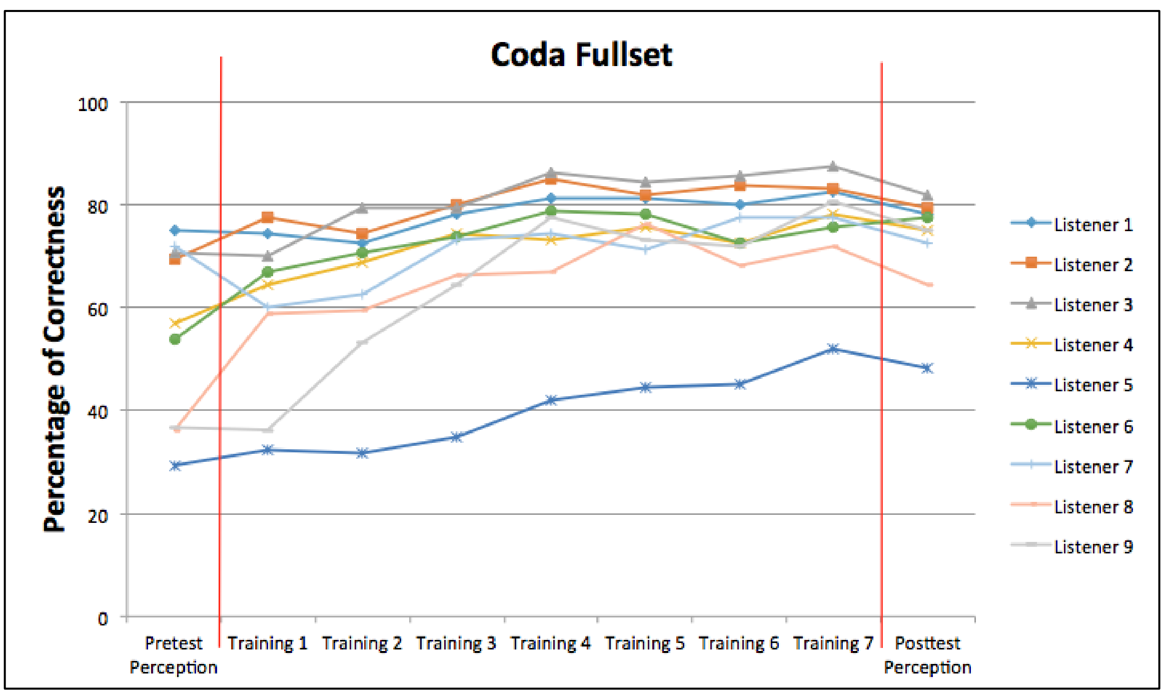


Figure 4-14: Coda Fulllset Listeners' Scores of Easy Segments from Pretest to Posttest

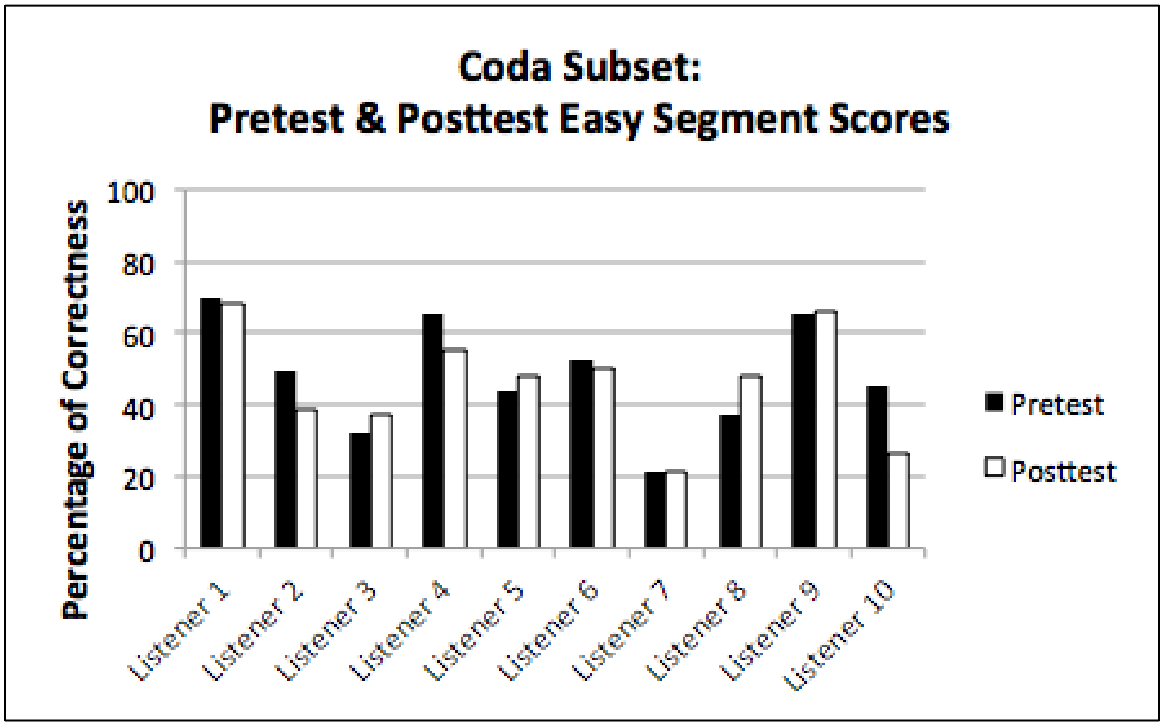


Figure 4-15: Coda Subset Listeners' Scores of Easy Segments from Pretest and posttest

Figure 4-14 shows that coda fullset group listeners' easy segment perception scores increased gradually from the first training session to the last training session. And, their scores in the perception posttest decreased a little bit from their scores in the last training session. Figure 4-15 shows that some of the coda subset group listeners' easy segment perception scores decreased a lot in the posttest (i.e., Listeners 2, 4, and 10), while other listeners' scores dropped a little bit in the posttest (i.e., Listeners 1 and 6). Also, some of the listeners' score increased a little bit in the posttest (i.e., Listeners 3, 5, and 9), except Listener 8 whose scores increased greatly in the posttest. When comparing the coda fullset group listeners' easy segment perception posttest scores with those of the coda subset group listeners, the easy segment perception posttest scores of the coda fullset group listeners seemed to be better than those of the coda subset group listeners. The easy segment perception posttest scores of the coda fullset group ranged from 48% to 82%, while those of the subset group ranged from 21% to 68%. Hence, I conducted an independent t-test to see whether the benefit of the fullset training could be shown for the easy codas (e.g., the difference between the fullset group's scores and the subset group's scores at the posttest.) However, the independent t-test showed that there was no significant different between the coda fullset group's easy segment scores and those of the coda subset group in the posttest [$t(17) = 4.342$ ($p > .05$, two-tailed)]. The easy segment scores of both groups in the perception pretests were not significantly different either [$t(17) = .556$ ($p > 0.5$, two-tailed)].

4. Segment Analyses: Improvement of Each Segment

While the previous section focuses on the listeners' easy and difficult segment scores and those scores were analyzed separately, this section focuses on the difficult and easy segment perception scores in the pretest, training sessions, and posttest. These scores were also analyzed separately. This is because the easy segments were not trained in the subset groups (i.e., vowel subset, onset subset, and coda subset). Therefore, a separate analysis is necessary for the comparison of the two training techniques (i.e., Fullset vs. Subset) in order to reveal which type of training is the most effective in training the different segments investigated (i.e., vowels, onsets, and codas). Importantly, the learning patterns of vowel, onset, and coda are presented.

4.1 Vowel Fullset vs. Vowel Subset

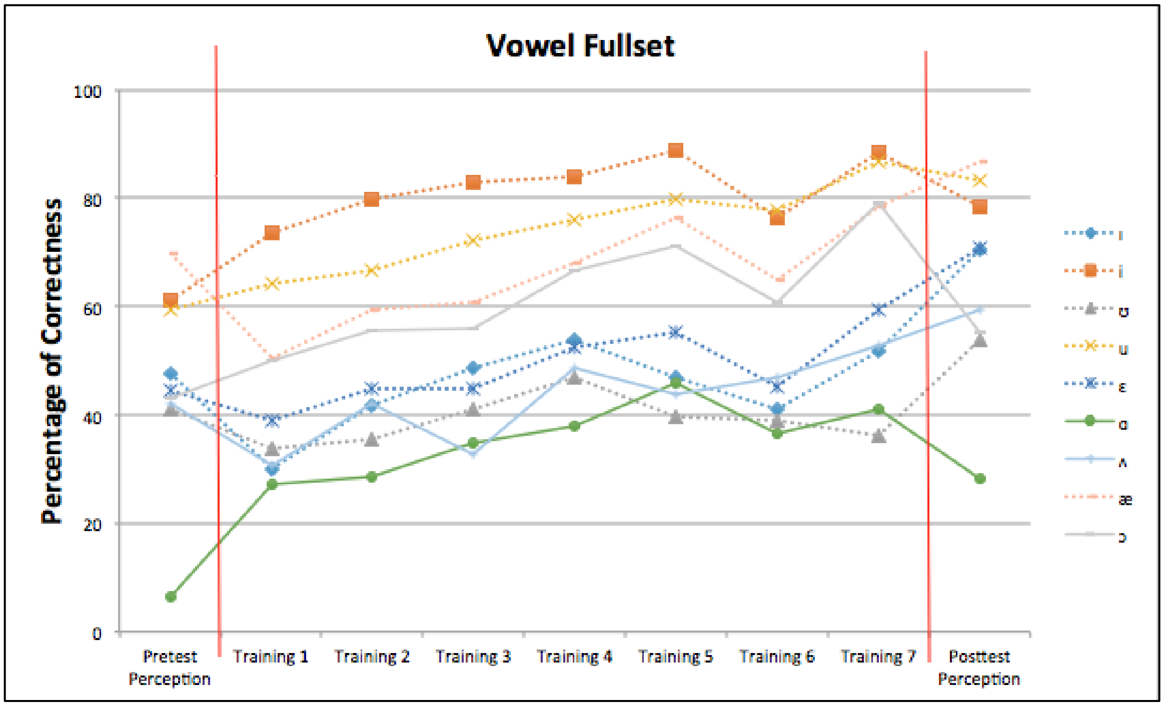


Figure 4-16: The Improvement of Each Vowel in Vowel Fullset

Figure 4-16 illustrates the scores of each segment in the vowel fullset training group in the perception pretest, seven training sessions, and perception posttest. The x–axis represents the training procedure: the pretest, seven training sessions, and posttest. The y–axis represents the percentage of correctness of each vowel. Each line represents each vowel and the markers on the line mark each stage along the procedure. Three solid lines represent three difficult vowels.

Figure 4-16 shows that the nine trained vowels (i.e., /ɪ i ʊ u ɛ ɑ ʌ æ ɔ/) improved gradually from the first training session to the last training session. A paired-sample t-test revealed that the scores of five vowels (i.e., /ʌ ɪ i u ɛ/) improved significantly in the perception posttest when comparing to their scores in the perception pretest, while the scores of four vowels (i.e., /ɑ ɔ ʊ æ/)

improved but not significantly at the .05 level in the perception posttest when comparing to their scores in the perception pretest (See Tables 4-1 and 4-3).

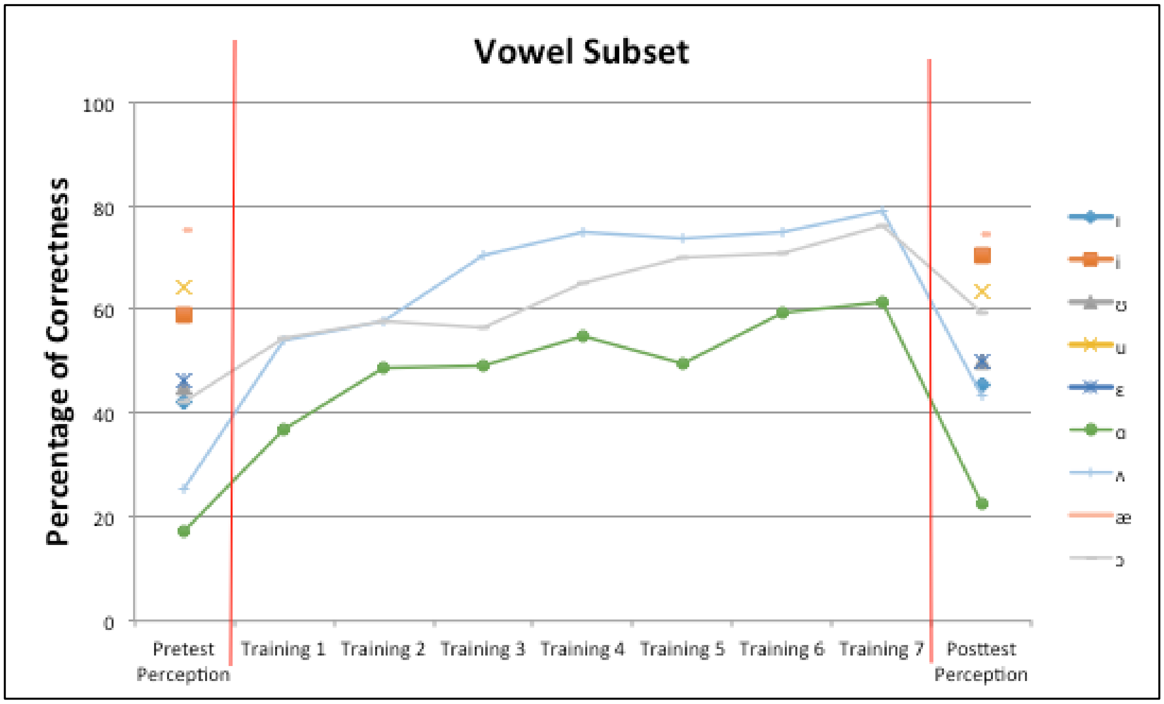


Figure 4-17: The Improvement of Each Vowel in Vowel Subset

Figure 4-17 illustrates the scores of each segment in the vowel subset training group in the perception pretest, seven training sessions, and perception posttest. The x–axis represents the training procedure: the pretest, seven training sessions, and posttest. The y–axis represents the percentage of correctness of each vowel. Each line represents each difficult trained vowel and the markers on the line mark each stage along the procedure.

Figure 4-17 shows that the three difficult vowels trained (i.e., /ɑ ʌ ɔ/) in the vowel subset training group improved from the first training session to the last training session. However, a paired-sample t-test revealed that the scores of three vowels (i.e., /ʌ ɔ i/) improved significantly in the perception posttest when comparing to their scores in the perception pretest. Among those three vowels, only two vowels (i.e., /ʌ ɔ/) were trained. On the other hand, the scores of four vowels (i.e., /ɑ ɪ ʊ ɛ/) improved but not significantly at the .05 level in the perception posttest when comparing to their scores in the perception pretest (See Tables 4-2 and 4-4). Among those four vowels, only one vowel (i.e., /ɑ/) was trained. And the scores of two vowels (i.e., /u æ/) became even lower in the perception posttest when comparing to their scores in the perception pretest (See Table 4-4).

4.1.1 Easy and Difficult Vowels in Vowel Fullset and Vowel Subset

Vowel Fullset Difficult Segments	Pretest		Posttest		A paired-sample t-test results (two-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation	
ɑ	6.48	9.57	28.24	29.74	$t(8) = -2.184$ ($p > .05$)
*ʌ	42.13	19.59	59.26	18.49	$t(8) = -2.579$ ($p < .05$)
ɔ	43.05	20.83	55.09	20.60	$t(8) = -1.945$ ($p > .05$)

Table 4-1: The Comparison of the Difficult Segment Perception Scores (%) in the Perception Pretest and the Perception Posttest in Vowel Fullset

Table 4-1 presents the results of the paired-sample t-test of the vowel fullset group's difficult segments (i.e., /ɑ ʌ ɔ/), the perception pretest mean scores, and the perception posttest mean scores of the same group. The mean scores of the three difficult segments (i.e., /ɑ ʌ ɔ/) as well as their standard deviation in both the perception pretest and the perception posttest are also presented.

Vowel Subset Difficult Segments	Pretest		Posttest		A paired-sample t-test results (two-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation	
ɑ	17.08	23.11	22.50	19.66	$t(8) = .839$ ($p > .05$)
**ʌ	25.42	18.47	43.33	11.15	$t(9) = -3.057$ ($p < .01$)
**ɔ	42.09	15.14	59.17	18.92	$t(9) = -3.480$ ($p < .01$)

Table 4-2: The Comparison of the Difficult Segment Perception Scores (%) in the Perception Pretest and the Perception Posttest in Vowel Subset

Table 4-2 presents the results of the paired-sample t-test of the vowel subset group's difficult segments (i.e., /ɑ ʌ ɔ/), the perception pretest mean scores, and the perception posttest mean scores of the same group. The mean scores of the three difficult segments (i.e., /ɑ ʌ ɔ/) as well as their standard deviation in both the perception pretest and the perception posttest are also presented.

After the seven training sessions, the scores of one difficult trained vowel (i.e., /ʌ/) of the vowel fullset group improved significantly in the perception posttest when comparing to its scores in the perception pretest, while the scores of two difficult trained vowels (i.e., /ʌ ɔ/) of the vowel subset group improved significantly in the perception posttest when comparing to their scores in the perception pretest.

Vowel Fullset Easy Segments	Pretest		Posttest		A paired-sample t-test results (two-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation	
**ɪ	47.69	22.06	70.37	21.80	$t(8) = -3.113$ ($p < .01$)
**i	61.11	20.10	78.24	18.25	$t(8) = -3.255$ ($p < .01$)
ʊ	41.20	13.89	53.70	25.04	$t(8) = -1.847$ ($p > .05$)
**u	59.26	14.40	83.33	2.08	$t(8) = -5.123$ ($p < .01$)
**ɛ	44.44	19.10	70.83	11.97	$t(8) = -5.429$ ($p < .01$)
æ	69.91	28.63	86.57	14.85	$t(8) = -2.113$ ($p > .05$)

Table 4-3: The Comparison of the Easy Segment Perception Scores (%) in the Perception Pretest and the Perception Posttest in Vowel Fullset

Table 4-3 presents the results of the paired-sample t-test of the vowel fullset group’s easy segments (i.e., /ɪ i ʊ u ɛ æ/), the perception pretest mean scores, and the perception posttest mean scores of the same group. The mean scores of the six easy segments (i.e., /ɪ i ʊ u ɛ æ/) as well as their standard deviation in both the perception pretest and the perception posttest are also presented.

Vowel Subset Easy Segments	Pretest		Posttest		A paired-sample t-test results (two-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation	
ɪ	42.08	14.89	45.42	16.13	*t*(9) = -.885 (*p* > .05)
*i	58.75	20.74	70.42	18.68	*t*(9) = -2.232 (*p* < .05)
ʊ	44.99	7.56	50.00	13.61	*t*(9) = -1.141 (*p* > .05)
u	64.17	15.24	<u>63.33</u>	11.08	*t*(9) = .190 (*p* > .05)
ɛ	46.25	25.03	50.00	21.87	*t*(9) = -.467 (*p* > .05)
æ	75.42	23.53	<u>74.58</u>	22.43	*t*(9) = .216 (*p* > .05)

Table 4-4: The Comparison of the Easy Segment Perception Scores (%) in the Perception Pretest and the Perception Posttest in Vowel Subset

Table 4-4 presents the results of the paired-sample t-test of the vowel subset group's easy segments (i.e., /ɪ i ʊ u ɛ æ/), the perception pretest mean scores, and the perception posttest mean scores of the same group. The mean scores of the six easy segments (i.e., /ɪ i ʊ u ɛ æ/) as well as their standard deviation in both the perception pretest and the perception posttest are also presented.

After the seven training sessions, the scores of four easy trained vowels (i.e., /ɪ i u ɛ/) of the vowel fullset group improved significantly in the perception posttest when comparing to their scores in the perception pretest, while the scores of one easy untrained vowel (i.e., /i/) of the vowel subset group improved significantly in the perception posttest when comparing to its scores in the perception pretest. Also, the scores of the two easy untrained vowels (i.e., /u æ/) in the vowel subset group decreased in the perception posttest when comparing to their scores in the perception pretest, although their scores did not drop significantly. In sum, when considering the scores of both easy and difficult segments (i.e., /ɑ ʌ ɔ ɪ l ʊ u ɛ æ/), the listeners' vowel perception abilities of the vowel fullset group improved more than those of the vowel subset group.

4.2 Onset Fullset vs. Onset Subset

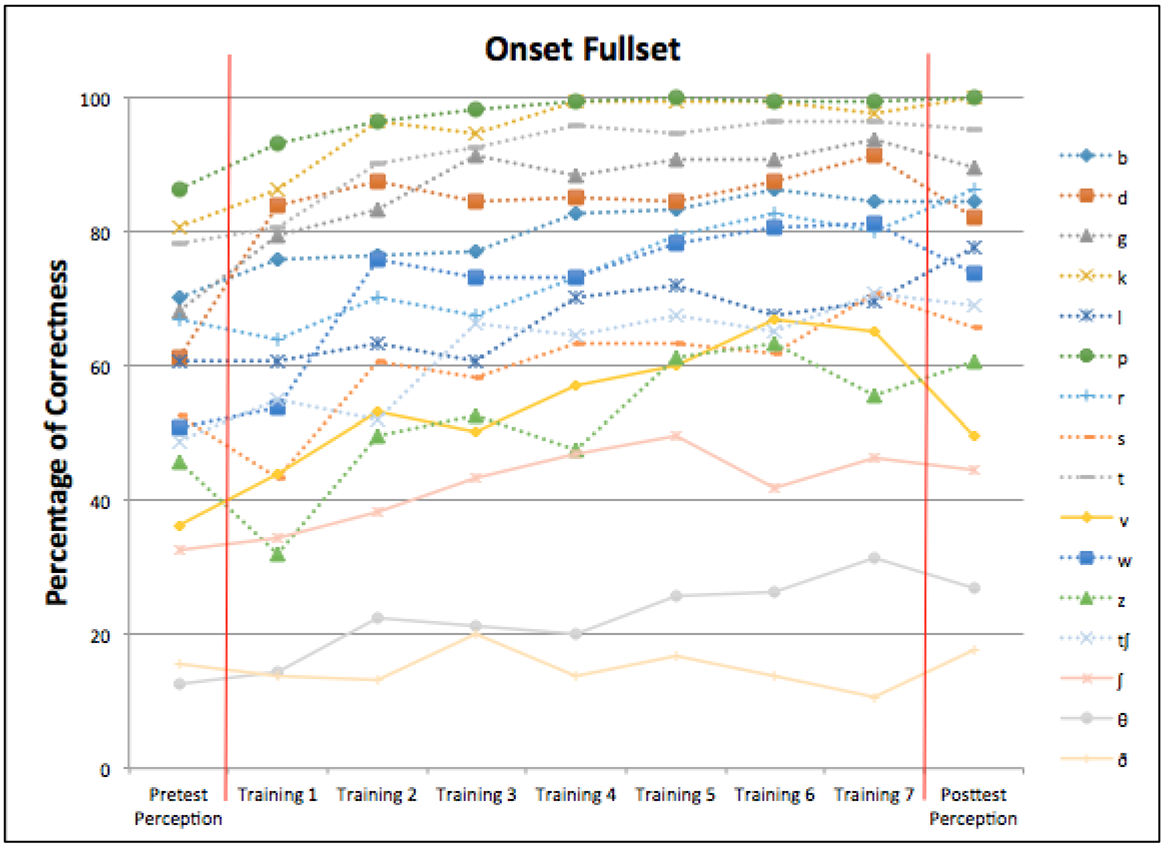


Figure 4-18: The Improvement of Each Onset in Onset Fullset

Figure 4-18 illustrates the scores of each segment in the onset fullset training group in the perception pretest, seven training sessions, and perception posttest. The x–axis represents the training procedure: the pretest, seven training sessions, and posttest. The y–axis represents the percentage of correctness of each onset. Each line represents each onset and the markers on the line mark each stage along the procedure. Four solid lines represent the four difficult onsets.

Figure 4-18 shows that the sixteen trained onsets (i.e., /b d g k l p r s t v w z tʃ ʃ θ ð/) improved gradually from the first training session to the last training session. A paired-sample t-test revealed that the scores of ten onsets (i.e., / b g k l p r t w z tʃ/) improved significantly in the perception posttest when comparing to their scores in the perception pretest, while the scores of six onsets (i.e., /d s v ʃ θ ð /) improved but not significantly at the .05 level in the perception posttest when comparing to their scores in the perception pretest (See Tables 4-5 and 4-7).

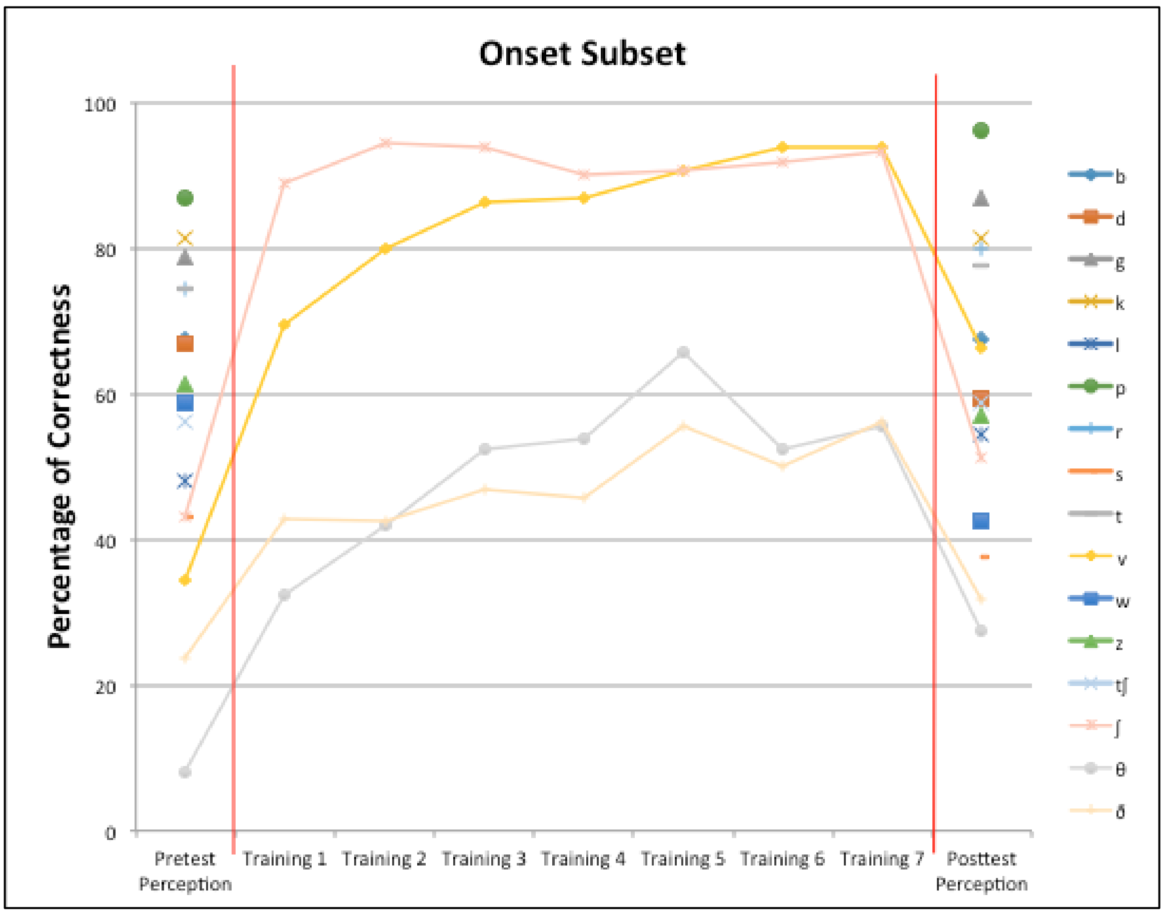


Figure 4-19: The Improvement of Each Onset in Onset Subset

Figure 4-19 illustrates the scores of each segment in the onset subset training group in the perception pretest, seven training sessions, and perception posttest. The x–axis represents the training procedure: the pretest, seven training sessions, and posttest. The y–axis represents the percentage of correctness of each onset. Each line represents each difficult trained onset and the markers on the line mark each stage along the procedure.

Figure 4-19 shows that the four difficult onsets trained (i.e., /v ʃ θ ð/) in the onset subset training group improved from the first training session to the last training session. However, a paired-sample t-test revealed that the scores of two onsets (i.e., /p v/) improved significantly in the perception posttest when comparing to their scores in the perception pretest. Between those two onsets, only one onset (i.e., /v/) was trained. On the other hand, the scores of eight onsets (i.e., /g l r t tʃ ʃ θ ð/) improved but not significantly at the .05 level in the perception posttest when comparing to their scores in the perception pretest (See Tables 4-6 and 4-8). Among those eight onsets, three onsets (i.e., /ʃ θ ð/) were trained. The scores of two onsets (i.e., /b k/) remained the same in the perception posttest when comparing to their scores in the perception pretest. And the scores of four onsets (i.e., /d s w z/) became even lower in the perception posttest when comparing to their scores in the perception pretest (See Table 4-8).

4.2.1 Easy and Difficult Onsets in Onset Fullset and Onset Subset

Onset Fullset Difficult Segments	Pretest		Posttest		A paired-sample t-test results (two-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation	
v	36.25	17.87	49.38	19.86	$t(9) = -1.622$ ($p > .05$)
ʃ	32.50	18.59	44.38	28.79	$t(9) = -1.285$ ($p > .05$)
θ	12.50	12.50	26.88	27.01	$t(9) = -1.830$ ($p > .05$)
ð	15.63	9.43	17.50	16.35	$t(9) = -.260$ ($p > .05$)

Table 4-5: The Comparison of the Difficult Segment Perception Scores (%) in the Perception Pretest and the Perception Posttest in Onset Fullset

Table 4-5 presents the results of the paired-sample t-test of the onset fullset group’s difficult segments (i.e., /v ʃ θ ð/), the perception pretest mean scores, and the perception posttest mean scores of the same group. The mean scores of the four difficult segments (i.e., /v ʃ θ ð/) as well as their standard deviation in both the perception pretest and the perception posttest are also presented.

Onset Subset Difficult Segments	Pretest		Posttest		A paired-sample t-test results (two-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation	
**v	34.38	14.51	66.25	13.88	$t(9) = -5.314$ ($p < .01$)
ʃ	43.13	13.96	51.25	18.35	$t(9) = -.946$ ($p > .05$)
θ	8.13	5.93	27.50	18.91	$t(9) = -1.830$ ($p > .05$)
ð	23.75	10.95	31.88	10.81	$t(9) = -1.709$ ($p > .05$)

Table 4-6: The Comparison of the Difficult Segment Perception Scores (%) in the Perception Pretest and the Perception Posttest in Onset Subset

Table 4-6 presents the results of the paired-sample t-test of the onset subset group's difficult segments (i.e., /v ʃ θ ð/), the perception pretest mean scores, and the perception posttest mean scores of the same group. The mean scores of the four difficult segments (i.e., /v ʃ θ ð/) as well as their standard deviation in both the perception pretest and the perception posttest are also presented.

After the seven training sessions, none of the scores of difficult trained onsets of the onset fullset group improved significantly in the perception posttest when comparing to its scores in the perception pretest, while the scores of one difficult trained onsets (i.e., /v/) of the onset subset group improved significantly in the perception posttest when comparing to their scores in the perception pretest.

Onset Fullset Easy Segments	Pretest		Posttest		A paired-sample t-test results (two-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation	
*b	70.00	12.78	84.38	14.59	$t(9) = -2.325$ ($p < .05$)
d	61.25	22.21	81.88	14.86	$t(9) = -2.150$ ($p > .05$)
*g	68.13	30.11	89.38	7.82	$t(9) = -2.429$ ($p < .05$)
**k	80.63	17.29	100.00	.00	$t(9) = -3.543$ ($p < .01$)
**l	60.63	14.15	77.50	19.37	$t(9) = -3.199$ ($p < .01$)
*p	86.25	18.59	100.00	.00	$t(9) = -2.339$ ($p < 0.5$)
**r	66.88	22.64	86.25	14.67	$t(9) = -4.043$ ($p < .01$)
s	52.50	20.88	65.63	22.68	$t(9) = -1.289$ ($p > .05$)
**t	78.13	19.15	95.00	6.46	$t(9) = -3.250$ ($p < .01$)
**w	50.63	24.38	73.75	14.97	$t(9) = -4.254$ ($p < .01$)
*z	45.63	17.93	60.63	22.25	$t(9) = -2.250$ ($p < .05$)
*tʃ	48.75	15.81	68.75	25.17	$t(9) = -2.551$ ($p < .05$)

Table 4-7: The Comparison of the Easy Segment Perception Scores (%) in the Perception Pretest and the Perception Posttest in Onset Fullset

Table 4-7 presents the results of the paired-sample t-test of the onset fullset group's easy segments (i.e., b d g k l p r s t w z tʃ/), the perception pretest mean scores, and the perception posttest mean scores of the same group. The mean scores of the twelve easy segments (i.e., b d g k l p r s t w z tʃ/) as well as their standard deviation in both the perception pretest and the perception posttest are also presented.

Onset Subset Easy Segments	Pretest		Posttest		A paired-sample t-test results (two-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation	
b	67.50	15.81	67.50	13.76	*t*(9) = .000 (*p* > .05)
d	66.88	11.80	<u>59.38</u>	11.51	*t*(9) = 1.857 (*p* > .05)
g	78.75	13.57	86.88	10.40	*t*(9) = -1.618 (*p* > .05)
k	81.25	14.43	81.25	14.43	*t*(9) = .000 (*p* > .05)
l	48.13	19.78	54.38	15.04	*t*(9) = -1.168 (*p* > .05)
*p	86.88	14.86	96.25	4.37	*t*(9) = -2.355 (*p* < 0.5)
r	74.38	18.74	80.00	13.11	*t*(9) = -1.132 (*p* > .05)
s	43.13	12.66	<u>37.50</u>	16.40	*t*(9) = 1.174 (*p* > .05)
t	74.38	21.13	77.50	22.09	*t*(9) = -.859 (*p* > .05)
**w	58.75	17.97	<u>42.50</u>	19.28	*t*(9) = 3.228 (*p* < .01)
z	61.25	16.35	<u>56.88</u>	11.95	*t*(9) = .651 (*p* > .05)
tʃ	56.25	19.54	58.75	23.05	*t*(9) = -.386 (*p* > .05)

Table 4-8: The Comparison of the Easy Segment Perception Scores (%) in the Perception Pretest and the Perception Posttest in Onset Subset

Table 4-8 presents the results of the paired-sample t-test of the onset subset group's easy segments (i.e., b d g k l p r s t w z tʃ/), the perception pretest mean scores, and the perception posttest mean scores of the same group. The mean scores of the twelve easy segments (i.e., b d g k l p r s t w z tʃ/) as well as their standard deviation in both the perception pretest and the perception posttest are also presented.

After the seven training sessions, the scores of ten easy trained onsets (i.e., /b g k l p r t w z tʃ/) of the onset fullset group improved significantly in the perception posttest when comparing to their scores in the perception pretest, while the scores of one easy untrained onset (i.e., /p/) of the onset subset group improved significantly in the perception posttest when comparing to their scores in the perception pretest. And the scores of the four easy untrained onsets (i.e., /d s w z/) of the onset subset group decreased in the perception posttest when comparing to their scores in the perception pretest. Although the scores of three onsets (i.e., /d s z/) in the onset subset group did not decrease significantly, the scores of one onset (i.e., /w/) decreased significantly in the perception posttest. In sum, when considering the scores of both easy and difficult segments (i.e., /v ʃ θ ð b d g k l p r s t w z tʃ/), the listeners' onset perception abilities of the onset fullset group improved more than those of the onset subset group.

4.3 Coda Fullset vs. Coda Subset

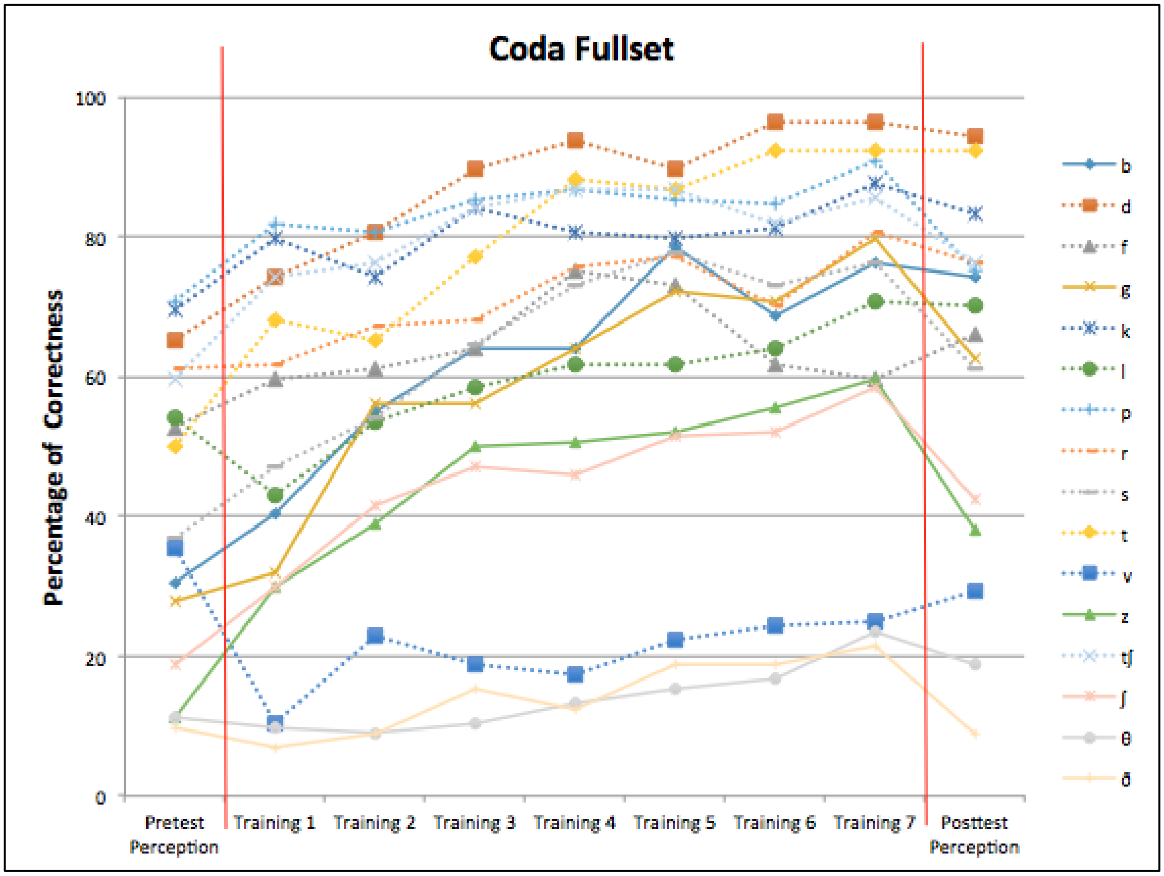


Figure 4-20: The Improvement of Each Coda in Coda Fullset

Figure 4-20 illustrates the scores of each segment in the coda fullset training group in the perception pretest, seven training sessions, and perception posttest. The x–axis represents the training procedure: the pretest, seven training sessions, and posttest. The y–axis represents the percentage of correctness of each coda. Each line represents each coda and the markers on the line mark each stage along the procedure. Six solid lines represent six difficult codas.

Figure 4-20 shows that the sixteen trained codas (i.e., /b d f g k l p r s t v z tʃ ʃ θ ð/) improved gradually from the first training session to the last training session. A paired-sample t-test revealed that the scores of eight codas (i.e., /b d g l s t z tʃ/) improved significantly in the perception posttest when comparing to their scores in the perception pretest, while the scores of six codas (i.e., /f k p r ʃ θ/) improved but not significantly at the .05 level in the perception posttest when comparing to their scores in the perception pretest. The scores of two codas (i.e., /v ð/) became even lower in the perception posttest when comparing to the perception pretest (See Tables 4-9 and 4-11).

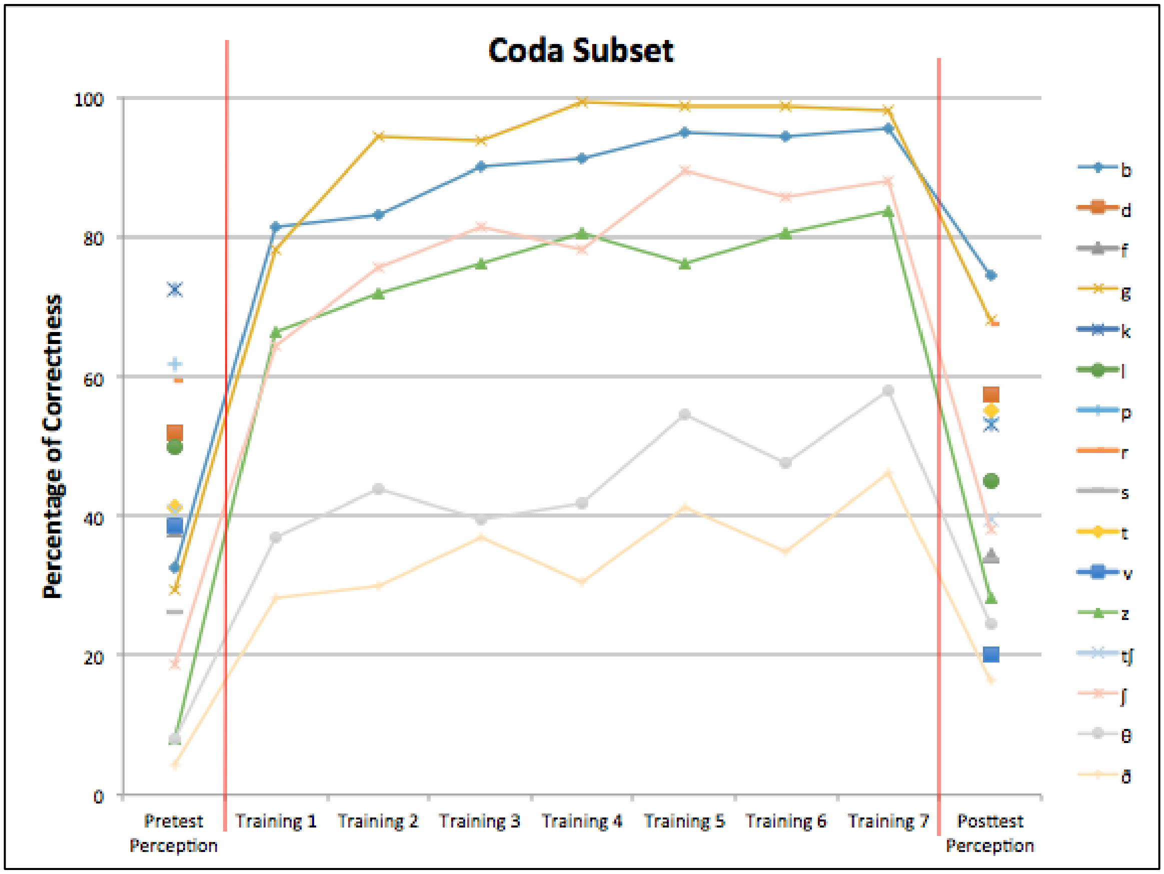


Figure 4-21: The Improvement of Each Coda in Coda Subset

Figure 4-21 illustrates the scores of each segment in the coda subset training group in the perception pretest, seven training sessions, and perception posttest. The x–axis represents the training procedure: the pretest, seven training sessions, and posttest. The y–axis represents the percentage of correctness of each coda. Each line represents each difficult trained coda and the markers on the line mark each stage along the procedure.

Figure 4-21 shows that the six difficult codas trained (i.e., /b g z ʃ θ ð/) in the coda subset training group improved from the first training session to the last training session. A paired-sample t-test revealed that the scores of all six trained codas (i.e., /b g z ʃ θ ð/) improved significantly in the perception posttest when comparing to their scores in the perception pretest (See Table 4-10). On the other hand, the scores of four codas (i.e., /d r s t/) improved but not significantly at the .05 level in the perception posttest when comparing to their scores in the perception pretest (See Table 4-12). And the scores of six untrained codas (i.e., /f k l p v tʃ/) became even lower in the perception posttest when comparing to their scores in the perception pretest. Among those six untrained codas, the scores of two codas (i.e., /k v/) dropped significantly in the perception posttest (See Table 4-12).

4.3.1 Easy and Difficult Codas in Coda Fullset and Coda Subset

Coda Fullset Difficult Segments	Pretest		Posttest		A paired-sample t-test results (two-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation	
**b	30.56	19.87	74.31	20.83	$t(8) = -7.000$ ($p < .01$)
**g	27.78	15.35	62.50	10.37	$t(8) = -8.575$ ($p < .01$)
**z	11.11	11.60	38.19	24.50	$t(8) = -4.670$ ($p < .01$)
ʃ	18.75	6.99	42.36	37.47	$t(8) = -1.734$ ($p > .05$)
θ	11.11	8.14	18.75	13.98	$t(8) = -1.417$ ($p > .05$)
ð	9.72	9.43	<u>9.03</u>	10.42	$t(8) = .155$ ($p > .05$)

Table 4-9: The Comparison of the Difficult Segment Perception Scores (%) in the Perception Pretest and the Perception Posttest in Coda Fullset

Table 4-9 presents the results of the paired-sample t-test of the coda fullset group’s difficult segments (i.e., /b g z ʃ θ ð/), the perception pretest mean scores, and the perception posttest mean scores of the same group. The mean scores of the six difficult segments (i.e., /b g z ʃ θ ð/) as well as their standard deviation in both the perception pretest and the perception posttest are also presented.

Coda Subset Difficult Segments	Pretest		Posttest		A paired-sample t-test results (two-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation	
**b	32.50	16.62	74.38	21.94	*t*(9) = -6.230 (*p* < .01)
**g	29.38	12.52	68.13	18.27	*t*(9) = -5.519 (*p* < .01)
**z	8.13	8.86	28.13	16.99	*t*(9) = -4.147 (*p* < .01)
*ʃ	18.75	11.02	38.13	26.26	*t*(9) = -2.250 (*p* < .05)
**θ	8.13	7.82	24.38	15.44	*t*(9) = -3.474 (*p* <.01)
**ð	4.38	6.62	16.25	14.19	*t*(9) = -3.243 (*p* < .01)

Table 4-10: The Comparison of the Difficult Segment Perception Scores (%) in the Perception Pretest and the Perception Posttest in Coda Subset

Table 4-10 presents the results of the paired-sample t-test of the coda subset group's difficult segments (i.e., /b g z ʃ θ ð/), the perception pretest mean scores, and the perception posttest mean scores of the same group. The mean scores of the six difficult segments (i.e., /b g z ʃ θ ð/) as well as their standard deviation in both the perception pretest and the perception posttest are also presented.

After the seven training sessions, the scores of three difficult trained codas (i.e., /b g z/) of the coda fullset group improved significantly in the perception posttest when comparing to their scores in the perception pretest. The scores of one difficult trained coda (i.e., /ð/) were slightly and insignificantly lower in the perception posttest when comparing to its score in the perception pretest. On the other hand, the scores of six difficult trained codas (i.e., /b g z ʃ θ ð/) of the coda subset group improved significantly in the perception posttest when comparing to their scores in the perception pretest.

Coda Fullset Easy Segments	Pretest		Posttest		A paired-sample t-test results (two-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation	
**d	65.28	19.04	94.44	4.89	*t*(8) = -5.029 (*p* < .01)
f	52.78	34.11	65.97	29.17	*t*(8) = -1.520 (*p* > .05)
k	69.44	19.38	83.33	12.10	*t*(8) = -1.949 (*p* > .05)
*l	54.17	15.93	70.14	7.64	*t*(8) = -2.749 (*p* < .05)
p	70.83	30.78	75.00	24.41	*t*(8) = -.571 (*p* > .05)
r	61.11	35.46	76.39	31.68	*t*(8) = -1.559 (*p* > 0.5)
*s	36.81	18.87	61.11	13.90	*t*(8) = -2.780 (*p* < .05)
**t	50.00	22.32	92.36	10.26	*t*(8) = -7.716 (*p* < .01)
v	35.42	15.31	<u>29.17</u>	17.12	*t*(8) = 1.225 (*p* > .05)
**tʃ	59.72	16.27	76.39	17.62	*t*(8) = -3.491 (*p* < .01)

Table 4-11: The Comparison of the Easy Segment Perception Scores (%) in the Perception Pretest and the Perception Posttest in Coda Fullset

Table 4-11 presents the results of the paired-sample t-test of the coda fullset group's easy segments (i.e., /d f k l p r s t v tʃ/), the perception pretest mean scores, and the perception posttest mean scores of the same group. The mean scores of the ten easy segments (i.e., /d f k l p r s t v tʃ/) as well as their standard deviation in both the perception pretest and the perception posttest are also presented.

Coda Subset Easy Segments	Pretest		Posttest		A paired-sample t-test results (two-tailed)
	Mean	Std. Deviation	Mean	Std. Deviation	
d	51.88	17.44	57.50	22.59	*t*(9) = -.916 (*p* > .05)
f	38.13	29.97	<u>34.38</u>	23.99	*t*(9) = .854 (*p* > .05)
*k	72.50	16.72	<u>53.13</u>	18.69	*t*(9) = 2.844 (*p* < .05)
l	50.00	19.09	<u>45.00</u>	16.35	*t*(9) = .811 (*p* >.05)
p	61.88	24.38	<u>53.75</u>	18.45	*t*(9) = 1.049 (*p* > .05)
r	59.38	25.56	67.50	27.45	*t*(9) = -2.177 (*p* > 0.5)
s	26.25	30.31	33.75	29.20	*t*(9) = -1.616 (*p* > .05)
t	41.25	25.04	55.00	27.45	*t*(9) = -2.181 (*p* > .05)
**v	38.75	24.08	<u>20.00</u>	14.67	*t*(9) = 3.451 (*p* < .01)
tʃ	40.63	27.83	<u>39.38</u>	30.63	*t*(9) = .162 (*p* > .05)

Table 4-12: The Comparison of the Easy Segment Perception Scores (%) in the Perception Pretest and the Perception Posttest in Coda Subset

Table 4-12 presents the results of the paired-sample t-test of the coda subset group's easy segments (i.e., /d f k l p r s t v tʃ/), the perception pretest mean scores, and the perception posttest mean scores of the same group. The mean scores of the ten easy segments (i.e., /d f k l p r s t v tʃ/) as well as their standard deviation in both the perception pretest and the perception posttest are also presented.

After the seven training sessions, the scores of five easy trained onsets (i.e., /d l s t tʃ/) of the coda fullset group improved significantly in the perception posttest when comparing to their scores in the perception pretest, while none of the scores of easy untrained codas of the coda subset group improved significantly in the perception posttest when comparing to its scores in the perception pretest. And the scores of the six easy untrained codas (i.e., /f k l p v tʃ/) of the coda subset group decreased in the perception posttest when comparing to their scores in the perception pretest. Although the scores of four codas (i.e., /f l p tʃ/) in the coda subset group did not decrease significantly, the scores of two codas (i.e., /k v/) decreased significantly in the perception posttest. In sum, when considering the scores of both easy and difficult segments (i.e., /b g z ʃ θ ð d f k l p r s t v tʃ/), the listeners' coda perception abilities of the coda fullset group improved more than those of the coda subset group.

5. The Generalization to New Talkers
5.1 Generalization to a New Talker in Vowel Fullset

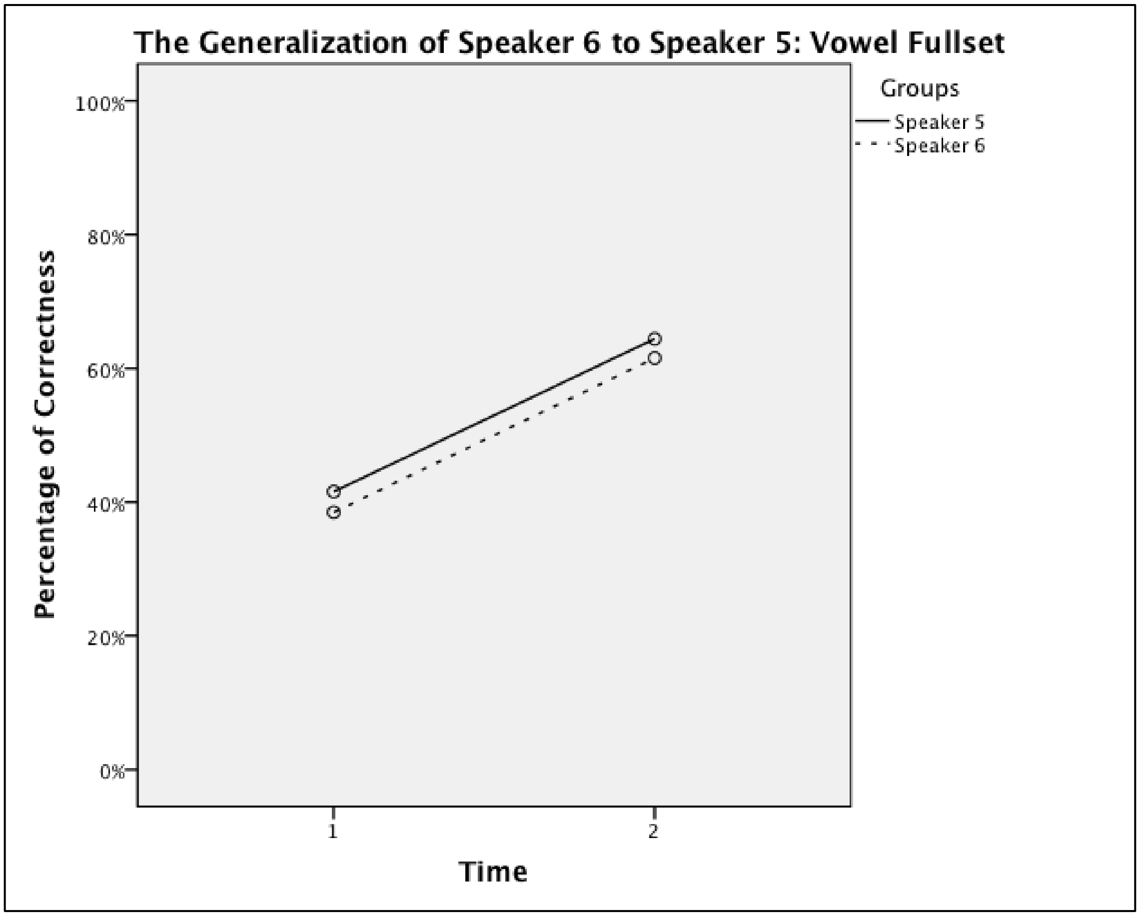


Figure 4-22: The Perception Generalization from Speaker 6 to 5 in Vowel Fullset

Figure 4-22 shows the generalization of the vowel perception abilities from Speaker 6 to Speaker 5 of the vowel fullset perception training group. The x–axis represents the two time points, with “1” representing the perception pretest and “2” representing the perception posttest. The y-axis represents the percentage of correctness. The dashed line represents Speaker 6 and the solid line represents Speaker 5.

The generalization from one talker to a new talker was analyzed in a two-way mixed-design ANOVA with *time* (pretest and posttest) as within-subjects and

groups (Speakers 5 and 6) as a between-subjects factor. There was a main effect of *time*, $F(1, 16) = 59.194$, $p < .01$, indicating that there were changes over time in the vowel perception scores of correctness from the pretest to the posttest across the two different speakers (i.e., Speakers 5 and 6). However, there was no main effect of *group*, $F(1,16) = .397$, $p > .05$, indicating that the speakers' differences of the average across the pre- and the posttest did not differ from each other. Importantly, there was no significant interaction between *time* and *groups*, $F(1,16) = .001$ $p > .05$. This indicates that the changes of the vowel perception scores of correctness over time from the pretest to the posttest were equivalent between the two speakers (i.e., Speakers 5 and 6).

In sum, there was no significant difference between two speakers (i.e., Speakers 5 and 6) in both the perception pretest and the perception posttest. And the mean scores of the vowel perception abilities from both speakers (i.e., Speakers 5 and 6) increased over time. Therefore, I conclude that the vowel fullset group listeners were able to generalize their vowel perception abilities trained by Speaker 6 in the training sessions to the untrained Speaker 5 in the posttest.

5.2 Generalization to a New Talker in Vowel Subset

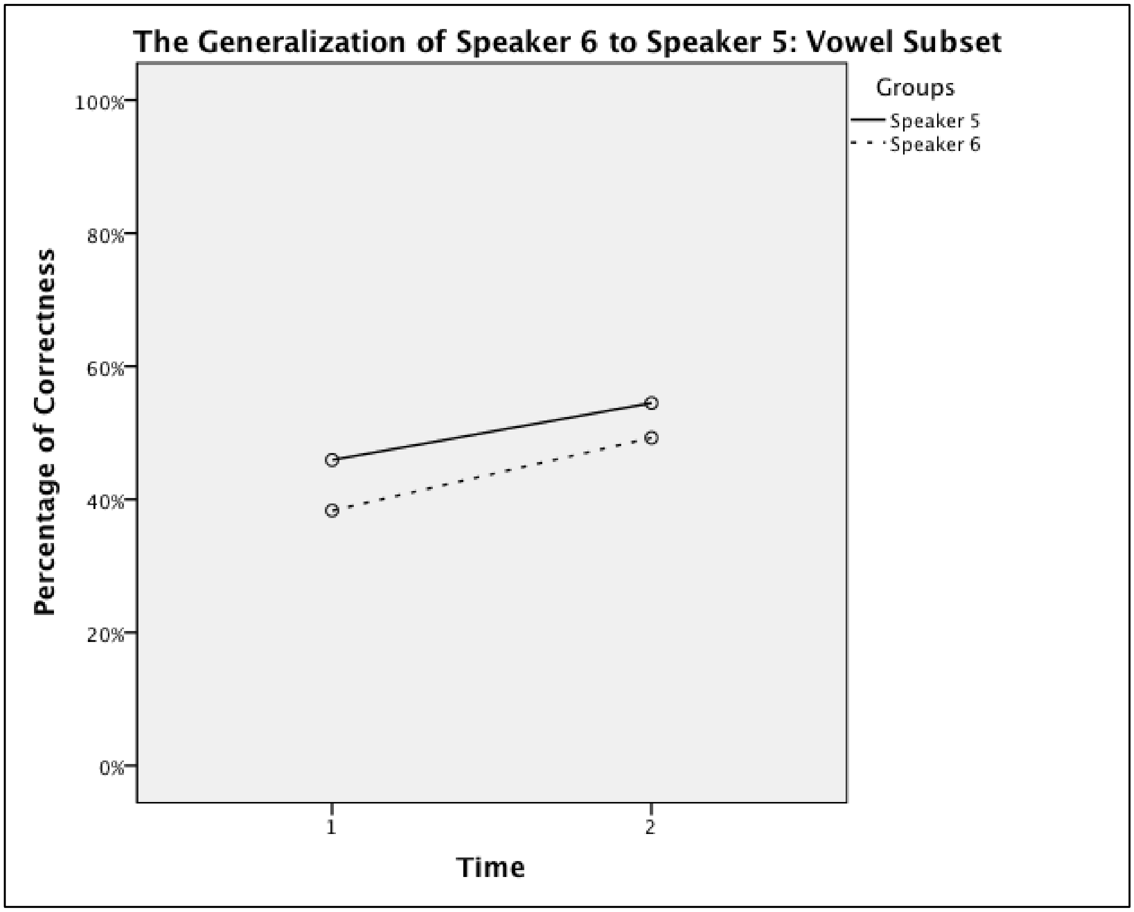


Figure 4-23: The Perception Generalization from Speaker 6 to 5 in Vowel Subset

Figure 4.23 shows the generalization of the vowel perception abilities from Speaker 6 to Speaker 5 of the vowel subset perception training group. The x–axis represents the two time points, with “1” representing the perception pretest and “2” representing the perception posttest. The y-axis represents the percentage of correctness. The dashed line represents Speaker 6 and the solid line represents Speaker 5.

The generalization from one talker to a new talker was analyzed in a two-way mixed-design ANOVA with *time* (pretest and posttest) as within-subjects and *groups* (Speakers 5 and 6) as a between-subjects factor. There was a main effect of *time*, $F(1,18) = 14.827$, $p < .01$, indicating that there were changes over time in the vowel perception scores of correctness from the pretest to the posttest across the two different speakers (i.e., Speakers 5 and 6). However, there was no main effect of *group*, $F(1,18) = 1.811$, $p > .05$, indicating that the speakers' differences of the average across the pre- and the posttest did not differ from each other. Importantly, there was no significant interaction between *time* and *groups*, $F(1,18) = .219$, $p > .05$. This indicates that the changes of the vowel perception scores of correctness over time from the pretest to the posttest were equivalent between the two speakers (i.e., Speakers 5 and 6).

In sum, there was no significant difference between two speakers (i.e., Speakers 5 and 6) in both the perception pretest and the perception posttest. And the mean scores of the vowel perception abilities from both speakers (i.e., Speakers 5 and 6) increased over time. Therefore, I conclude that the vowel subset group listeners were able to generalize their vowel perception abilities trained by Speaker 6 in the training sessions to the untrained Speaker 5 in the posttest.

5.3 Generalization to a New Talker in Onset Fullset

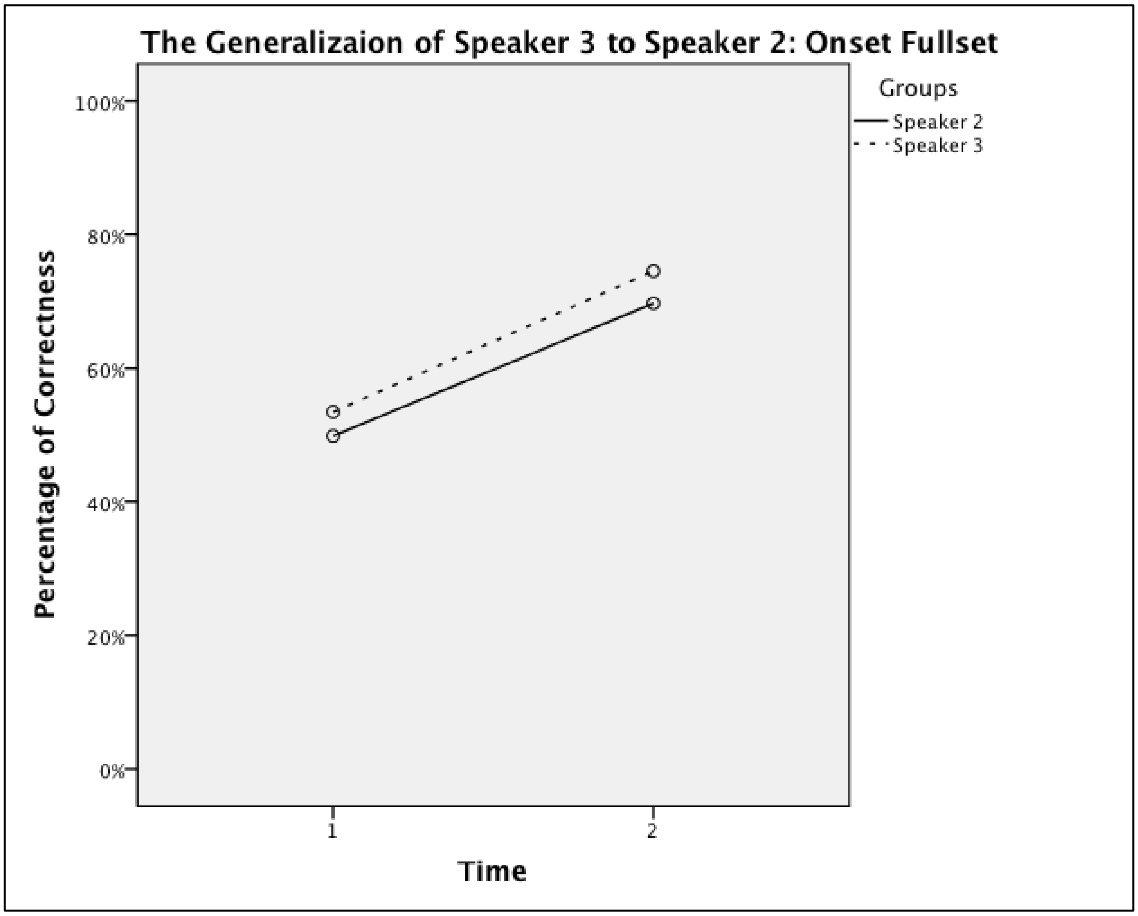


Figure 4-24: The Perception Generalization from Speaker 3 to 2 in Onset Fullset

Figure 4-24 shows the generalization of the onset perception abilities from Speaker 3 to Speaker 2 of the onset fullset perception training group. The x–axis represents the two time points, with “1” representing the perception pretest and “2” representing the perception posttest. The y-axis represents the percentage of correctness. The dashed line represents Speaker 3 and the solid line represents Speaker 2.

The generalization from one talker to a new talker was analyzed in a two-way mixed-design ANOVA with *time* (pretest and posttest) as within-subjects and

groups (Speakers 2 and 3) as a between-subjects factor. There was a main effect of *time*, $F(1,18) = 117.466$, $p < .01$, indicating that there were changes over time in the onset perception scores of correctness from the pretest to the posttest across the two different speakers (i.e., Speakers 2 and 3). However, there was no main effect of *group*, $F(1,18) = 1.313$, $p > .05$, indicating that the speakers' differences of the average across the pre- and the posttest did not differ from each other. Importantly, There was no significant interaction between *time* and *groups*, $F(1,18) = 3.906$, $p > .05$. This indicates that the changes of the onset perception scores of correctness over time from the pretest to the posttest were equivalent between the two speakers (i.e., Speakers 2 and 3).

In sum, there was no significant difference between two speakers (i.e., Speakers 2 and 3) in both the perception pretest and the perception posttest. And the mean scores of the onset perception abilities from both speakers (i.e., Speakers 2 and 3) increased over time. Therefore, I conclude that the onset fullset group listeners were able to generalize their onset perception abilities trained by Speaker 3 in the training sessions to the untrained Speaker 2 in the posttest.

5.4 Generalization to a New Talker in Onset Subset

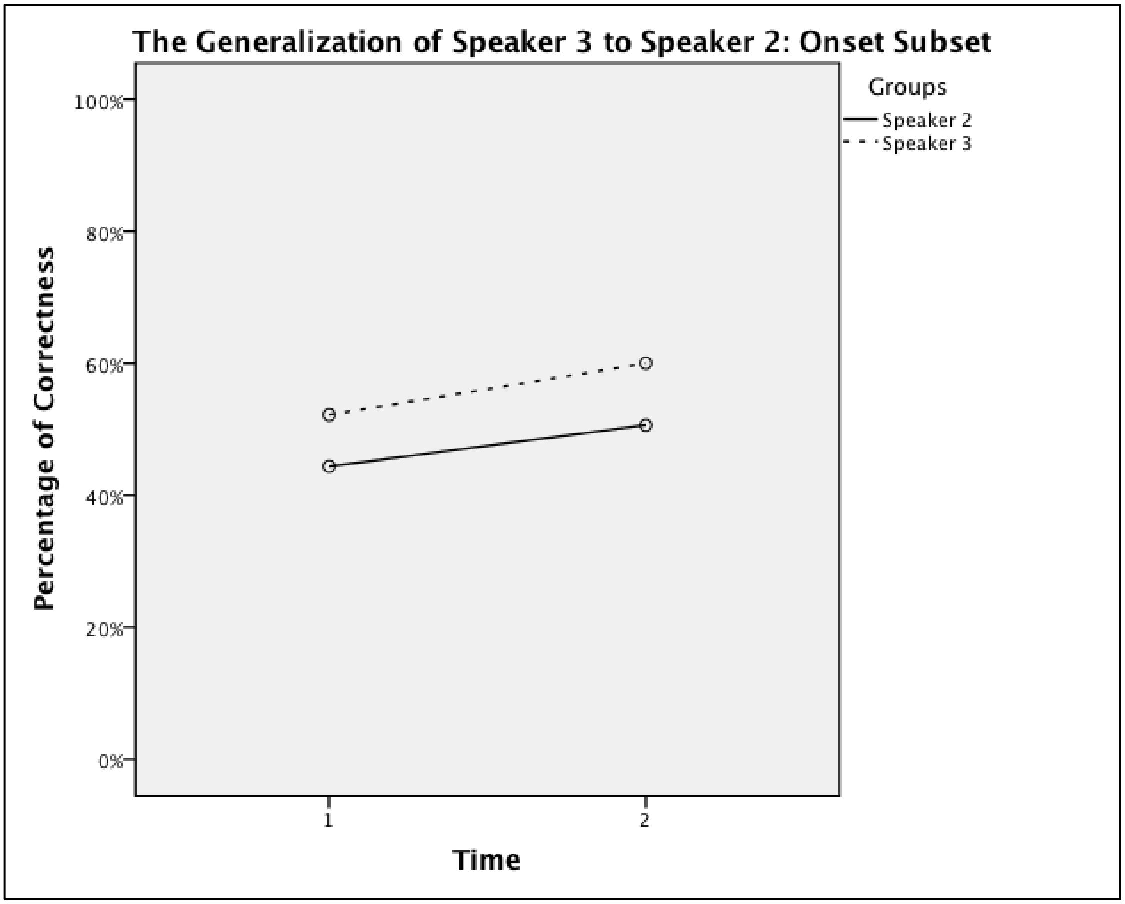


Figure 4-25: The Perception Generalization from Speaker 3 to 2 in Onset Subset

Figure 4-25 shows the generalization of the onset perception abilities from Speaker 3 to Speaker 2 of the onset subset perception training group. The x-axis represents the two time points, with “1” representing the perception pretest and “2” representing the perception posttest. The y-axis represents the percentage of correctness. The dashed line represents Speaker 3 and the solid line represents Speaker 2.

The generalization from one talker to a new talker was analyzed in a two-way mixed-design ANOVA with *time* (pretest and posttest) as within-subjects and

groups (Speakers 2 and 3) as a between-subjects factor. There was a main effect of *time*, $F(1,18) = 17.497$, $p < .01$, indicating that there were changes over time in the onset perception scores of correctness from the pretest to the posttest across the two different speakers (i.e., Speakers 2 and 3). Also, there was a main effect of *group*, $F(1,18) = 10.479$, $p < .01$, indicating that the speakers' differences of the average across the pre- and the posttest differed from each other. However, there was no significant interaction between *time* and *groups*, $F(1,18) = .218$, $p > .05$. This indicates that the changes of the onset perception scores of correctness over time from the pretest to the posttest were equivalent between the two speakers (i.e., Speakers 2 and 3). In sum, there was significant difference between two speakers (i.e., Speakers 2 and 3) in both the perception pretest and the perception posttest, and the mean scores of the onset perception abilities from both speakers (i.e., Speakers 2 and 3) increased over time.

Follow-up *post hoc* test using Bonferroni revealed that the listeners' scores between groups (i.e., Speakers 2 and 3) were significantly different both at the pretest ($p < .05$) and the posttest ($p < .01$). In sum, although there was significant difference between the two speakers (i.e., Speakers 2 and 3) in both the perception pretest and the perception posttest, the onset subset group listeners' mean scores of the onset perception abilities from both speakers (i.e., Speakers 2 and 3) increased over time in the same manner.

To confirm whether the onset subset group listeners were able to generalize their onset perception abilities trained by Speaker 2 in the training sessions to Speaker 3 in the posttest, a paired-sample t-test was conducted to see whether there was any significant difference between the improvement of the onset perception ability trained by Speaker 2 and tested by Speaker 3 after the onset subset group listeners were trained with only tokens produced by Speaker 3 in the training sessions. In order to conduct this analysis, the listeners' pretest scores from both speakers (i.e., Speakers 2 and 3) were subtracted by their posttest scores from the same two speakers (i.e., Speakers 2 and 3). Thus, the scores, which were the difference between the pretest and the posttest of each speaker, indicated what level of perception ability from the trained (i.e., Speaker 3) and the untrained speaker (i.e., Speaker 2) improved in the posttest. Then, the difference scores between the pretests and the posttests from the two speakers (i.e., Speakers 2 and 3) were compared using a paired-sample t-test.

The paired-sample t-test revealed no significant difference between the improvement of the onset perception ability from both speakers (i.e., Speakers 2 and 3), although the listeners were trained with only the tokens produced by Speaker 3 [$t(9) = -.621$, ($p > .05$)]. Thus, the onset subset group listeners were able to generalize their onset perception ability trained by Speaker 3 in the training sessions to the untrained Speaker 2 in the posttest.

5.5 Generalization to a New Talker in Coda Fullset

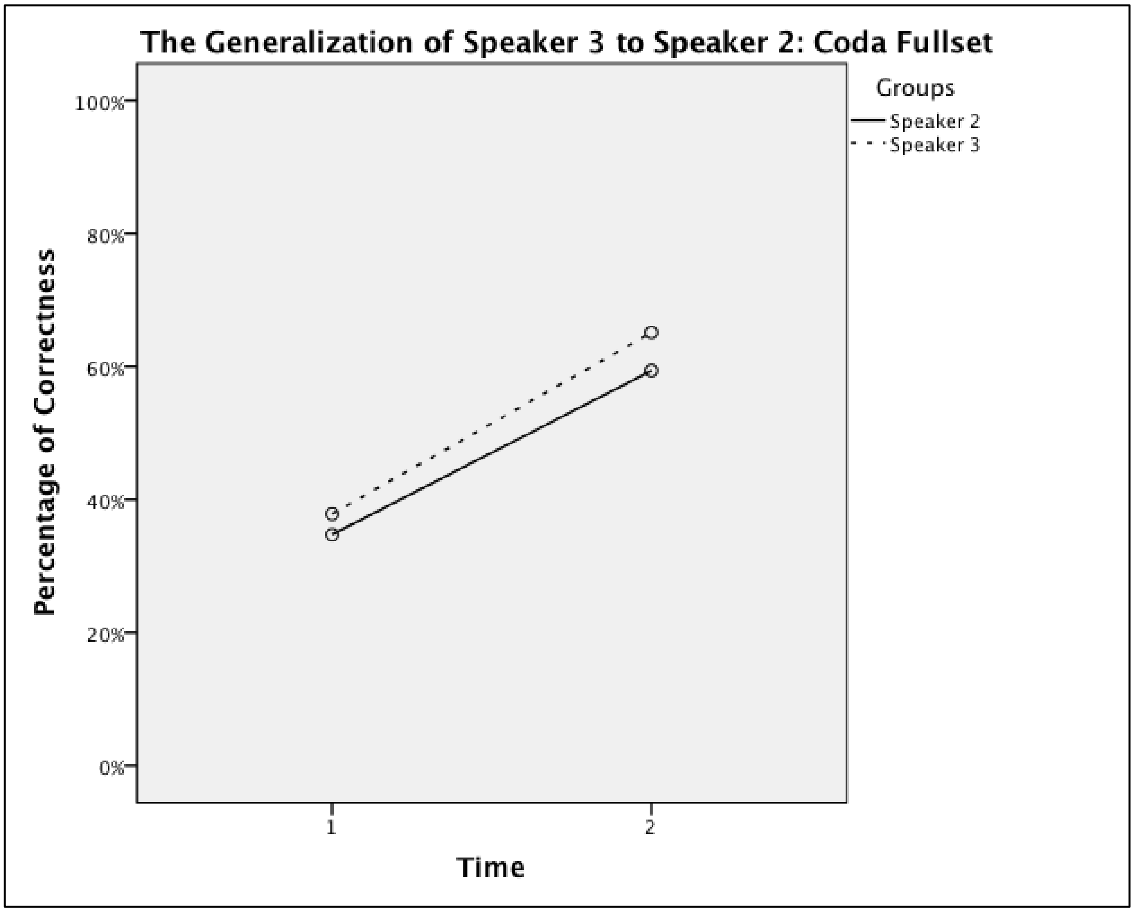


Figure 4-26: The Perception Generalization from Speaker 3 to 2 in Coda Fullset

Figure 4-26 shows the generalization of the coda perception abilities from Speaker 3 to Speaker 2 of the coda fullset perception training group. The x–axis represents the two time points, with “1” representing the perception pretest and “2” representing the perception posttest. The y-axis represents the percentage of correctness. The dashed line represents Speaker 3 and the solid line represents Speaker 2.

The generalization from one talker to a new talker was analyzed in a two-way mixed-design ANOVA with *time* (pretest and posttest) as within-subjects and *groups* (Speakers 2 and 3) as a between-subjects factor. There was a main effect of *time*, $F(1,16) = 89.559$, $p < .01$, indicating that there were changes over time in the coda perception scores of correctness from the pretest to the posttest across the two different speakers (i.e., Speakers 2 and 3). However, there was no main effect of *group*, $F(1,16) = .875$, $p > .05$, indicating that the speakers' differences of the average across the pre- and the post-test did not differ from each other. Importantly, there was no significant interaction between *time* and *groups*, $F(1,16) = 15.471$ ($p > .05$). This indicates that the changes of the coda perception scores of correctness over time from the pretest to the posttest were equivalent between the two speakers (i.e., Speakers 2 and 3).

In sum, there was no significant difference between two speakers (i.e., Speakers 2 and 3) in both the perception pretest and the perception posttest. And the mean scores of the coda perception abilities from both speakers (i.e., Speakers 2 and 3) increased over time. Therefore, I conclude that the coda fullset group listeners were able to generalize their coda perception abilities trained by Speaker 3 in the training sessions to the untrained Speaker 2 in the posttest.

5.6 Generalization to a New Talker in Coda Subset

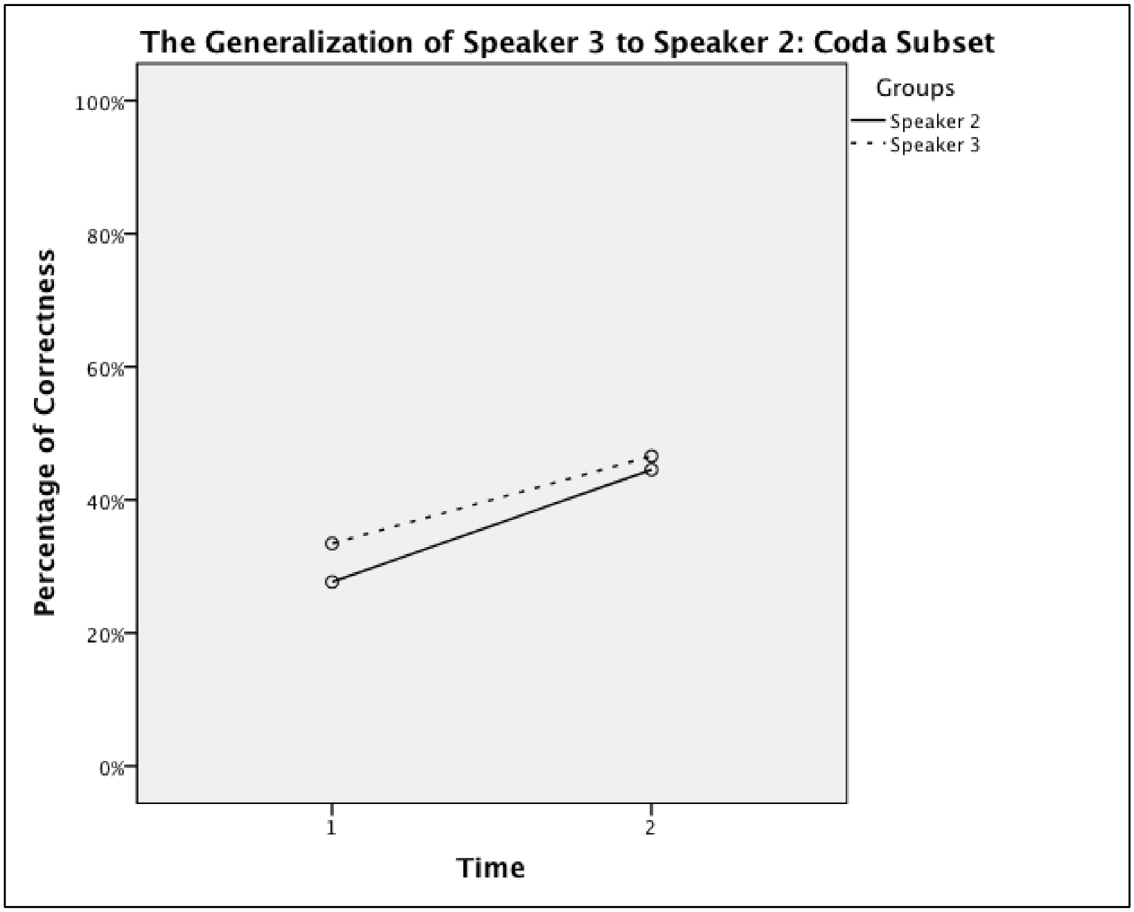


Figure 4-27: The Perception Generalization from Speaker 3 to 2 in Coda Subset

Figure 4-27 shows the generalization of the coda perception abilities from Speaker 3 to Speaker 2 of the coda subset perception training group. The x–axis represents the two time points, with “1” representing the perception pretest and “2” representing the perception posttest. The y-axis represents the percentage of correctness. The dashed line represents Speaker 3 and the solid line represents Speaker 2.

The generalization from one talker to a new talker was analyzed in a two-way mixed-design ANOVA with *time* (pretest and posttest) as within-subjects and

groups (Speakers 2 and 3) as a between-subjects factor. There was a main effect of *time*, $F(1,18) = 47.040$, $p < .01$, indicating that there were changes over time in the coda perception scores of correctness from the pretest to the posttest across the two different speakers (i.e., Speakers 2 and 3). However, there was no main effect of *group*, $F(1,18) = .578$, $p > .05$, indicating that the speakers' differences of the average across the pre- and the post-test did not differ from each other. Importantly, There was no significant interaction between *time* and *groups*, $F(1,18) = 34.782$, $p > .05$. This indicates that the changes of the coda perception scores of correctness over time from the pretest to the posttest were equivalent between the two speakers (i.e., Speakers 2 and 3).

In sum, there was no significant difference between two speakers (i.e., Speakers 2 and 3) in both the perception pretest and the perception posttest. And the mean scores of the coda perception abilities from both speakers (i.e., Speakers 2 and 3) increased over time. Therefore, I conclude that the coda subset group listeners were able to generalize their coda perception abilities trained by Speaker 3 in the training sessions to the untrained Speaker 2 in the posttest.

6. Summary

Section 2 showed that the fullset training technique worked more effectively than the subset technique in training the three different segments (i.e., vowels, onsets, and codas). In Section 3, the learner analyses were conducted to see the learners' learning patterns of easy and difficult segments of different segments investigated (i.e., vowels, onsets, and codas) in the two different training groups (i.e., Fullset vs. Subset). There was no significant difference between the two training groups (i.e., Fullset vs. Subset) in regards to training the easy and difficult segments of different segments investigated (i.e., vowels, onsets, and codas). Table 4-13 provides the summary of these analyses.

Segment	**Type of Training Set**	**Segment**	**An independent t-test results (two-tailed)**
Vowel	Fullset	Difficult	$t(17) = .794$, $p > .05$
	Subset		
	Fullset	Easy	$t(17) = .495$, $p > .05$
	Subset		
Onset	Fullset	Difficult	$t(18) = -1.664$, $p > .05$
	Subset		
	Fullset	Easy	$t(18) = 6.369$, $p > .05$
	Subset		
Coda	Fullset	Difficult	$t(17) = .621$, $p > .05$
	Subset		
	Fullset	Easy	$t(17) = 4.342$, $p > .05$
	Subset		

Table 4-13: The Summary of Learners' Easy and Difficult Segment Learning Patterns in the Six Groups

In Section 4, the segment analyses were conducted to see the learning patterns of easy and difficult segment groups of different segments investigated (i.e., vowels, onsets, and codas) in the two different training groups (i.e., Fullset vs. Subset). The results showed that the fullset training worked more effectively in training the three different types of segments (i.e., vowels, onsets, and codas) than the subset training. The fullset training groups (i.e., Vowel Fullset, Onset Fullset, and Coda Fullset) improved learners' perception abilities more than the subset training groups (i.e., Vowel Subset, Onset Subset, and Coda Subset) in that, a higher number of easy and difficult segments were found to improve significantly in the listeners' perception posttest scores. Importantly, the fullset training is better than the subset training because the performance of untrained segments decreased due to the subset training – this is the common observation throughout different training groups (i.e., vowels, onsets, and codas). In the last section, Thai listeners in every training group (i.e., Vowel Fullset, Vowel Subset, Onset Fullset, Onset Subset, Coda Fullset, and Coda Subset) were able to generalize their trained perception abilities to the new talkers.

Chapter 5

Discussion

1. Introduction

This chapter discusses findings of the study to answer the research questions, and also interesting results from the study. Section 2 explains the answers for the research questions (See page 76) in terms of the results from the study. This section also highlights the interaction between vowels and consonants, as well as other interesting findings. Section 3 provides the implications on speech perception trainings and pedagogical implications. And the last section suggests the directions for future study.

2. Answers for the Questions of the Study

2.1 Vowel Fullset vs. Subset in L1-Thai Learners of L2-English (Question 1's Answers)

This section answers the first question of this study based on the analyses of pooled scores of every segment, which is "Can the laboratory perceptual training using the full set training suggested in Nishi & Kewley-Port (2007) also be applied to L1-Thai learners' perceptual training of L2-English vowels?". The answer is "Yes". The laboratory perceptual training using the fullset training suggested in Nishi & Kewley-Port (2007) can be applied to L1-Thai learners' perceptual training of L2-English vowels. The supporting evidence comes from the comparison of the vowel fullset group learners' improvement and the vowel subset group learners' improvement. Although both the vowel fullset and the vowel subset groups improved after the training, the improvement was more significant in the vowel fullset group shown by the paired-sample t-test that the vowel fullset group' posttest scores were different from their pretest scores at $p < .01$, whereas the vowel subset group's posttest scores were different from their pretest scores at $p < .05$.

2.2 Onset Fullset vs. Subset in L1-Thai Learners of L2-English (Question 2's Answers)

This section answers the second question of this study based on the analyses of pooled scores of every segment, which is "Can the training set technique also be applied to the L1-Thai learners' perceptual training of L2-English *consonants*?". The answer is "Yes". The laboratory perceptual training using the fullset training suggested in Nishi & Kewley-Port (2007) can be applied to L1-Thai learners' perceptual training of L2-English consonants. The supporting evidence comes from the comparison of the onset fullset group learners' improvement and the onset subset group learners' improvement. Although both the onset fullset and the onset subset groups improved after the training, the improvement was more significant in the onset fullset group shown by the paired-sample t-test that the onset fullset group' posttest scores were different from their pretest scores at $p < .01$, whereas the onset subset group's posttest scores were different from their pretest scores at $p < .05$.

What is interesting here is that the patterns found with the onset training were similar to those of the vowel training, even though they were not identical.

The fullset training was found to be more effective than the subset training. This does not agree with the predictions of the current and the previous studies (Nishi & Kewley-Port, 2007) which predict that the training set technique results in a different pattern when comparing consonant training with vowel training. This is because the nature of consonants and vowels are quite different, such as different combinations of features, different acoustic properties, and different degree of constriction (See pages 52-54) (Mallen, 2005; McCombs, 2006; Nishi & Kewley-Port, 2007; Strange, 2007). However, Best & Tyler (2007) contended that although vowels are different physically and linguistically from consonants in many aspects, such as acoustic and articulatory properties, there are many findings on SLA adults' perception of L2 vowels reflect the patterns found with L2 consonants. This, therefore, explains the similar patterns found between the vowel and the onset trainings.

2.3 Coda Subset vs. Coda Fullset in L1-Thai Learners of L2-English (Question 2's Answers)

This section answers the second question of this study based on the analyses of pooled scores of every segment, which is "Can the training set technique also be applied to the L1-Thai learners' perceptual training of L2-English *consonants*?". The answer is "Yes". The laboratory perceptual training using the fullset training suggested in Nishi & Kewley-Port (2007) can be applied to L1-Thai learners' perceptual training of L2-English consonants. The supporting evidence comes from the comparison of the coda fullset group learners' improvement and the coda subset group learners' improvement. Although both the coda fullset and the coda subset groups improved after the training and the posttest scores of both groups were different from their pretest scores at $p < .01$, the improvement was more significant in the coda fullset group. This was tested by the *post hoc* test (Tukey HSD), which revealed that the difference between the pretest and the posttest scores of the coda fullset training group were significantly higher than those of the coda subset training group and the coda control group at the .01 level. Interestingly, the *post hoc* test (Tukey HSD) also showed that the difference between the pretest and the posttest scores of the coda subset training group were also significantly higher than that of the coda control group at the .05 level.

This makes the coda trainings a little bit different from the vowel and the onset trainings in that the difference between the pretest and the posttest scores of the vowel subset and the onset subset trainings were not significantly higher than those of their control groups. This signifies that the subset training technique works most effectively in training codas among three different types of segments (i.e., vowels, onsets, and codas). Nevertheless, a similar conclusion to the cases of vowel and onset can be drawn here in that the coda fullset training works more effectively than the coda subset training. As being previously mentioned, the results of the present study show the similar patterns between the vowel and the consonant training (i.e., between the vowel training and the onset and the coda trainings) despite the fact that vowels and consonants possess quite different characteristics (McCombs, 2006; Nishi & Kewley-Port, 2007: 1497; Strange, 2007). However, the evidence found in many studies that the perception of SLA adults' L2 vowels could reflect the patterns found with L2 consonants can account for the similarity between the vowel-training and the consonant-training patterns in the recent study (Best & Tyler, 2007).

2.4 Individual Segment Analyses (Question 3's Answers)

2.4.1 Vowel Fullset vs. Vowel Subset

This section provides an answer to the third question of the present study, which is "Which training set will be more effective in training the easy and difficult vowels?". The answer is that the vowel subset training worked more effectively in training the difficult vowels but after the training some of the untrained easy vowel perception abilities dropped, while the vowel fullset training worked more effectively when considering both the easy and the difficult vowels.

The vowel subset perception training appears to be better in terms of training the difficult segments because the scores of 2 out of 3 of the difficult trained vowels (i.e., /ʌ ɔ/) in the subset training group improved significantly in the perception posttest when compared to the perception pretest, while the scores of only 1 difficult trained vowel (i.e., /ʌ/) in the fullset training group improved significantly in the perception posttest when compared to the perception pretest. This is not surprising, since the listeners in the vowel subset group were trained with only 3 difficult segments (i.e., /ɑ ʌ ɔ/), whereas the listeners in the vowel fullset group were trained with both easy and difficult 9 total (i.e., /ɑ ʌ ɔ ɪ i ʊ u ɛ æ/).

However, with the same number of training sessions (i.e., seven training sessions), the vowel fullset perception training seems to be more effective than the vowel subset perception training. As shown in Table 4-1 to 4-4 that after going through the seven training sessions, Thai learners from the fullset group improved more vowel perception abilities than those of the subset group training. The scores of 5 vowels (i.e., /ʌ ɪ i u ɛ/) in the vowel fullset training group improved significantly in the perception posttest when being compared to their scores in the perception pretest. While the scores of only 3 vowels (i.e., /ʌ ɔ i/) in the vowel subset training group improved significantly in the perception posttest when being compared to their scores in the perception pretest.

Moreover, the scores of 2 untrained vowels (i.e., /u æ/) in the vowel subset training group became even lower in the perception posttest when being compared to the pretest, although their scores did not significantly drop (See Table 4-4). One thing that needs mentioning here is that the sudden drop between the last training session and the posttest of the vowel subset group might be due to the fact that the subset group had only a few choices of sounds to select during the training sessions, but the posttest had additional choices which were not available during the training sessions (See Figure 4-17). In sum, with the same number of training sessions the vowel fullset training group improved listeners' vowel perception abilities better than the vowel subset training group.

2.4.2 Onset Fullset vs. Onset Subset

This section provides answer to the third question of the current study, which is "Which training set will be more effective in training the easy and difficult consonant?". The answer is that the onset subset training worked more effectively in training the difficult onsets but after the training some of the untrained easy onset perception abilities dropped, while the onset fullset training worked more effectively in training when considering both the easy and the difficult onsets.

The onset training drew the similar pattern to that of the vowel training in that the onset subset perception training seems to be better in terms of training the difficult segments because the scores of 1 out of 4 of the difficult trained onsets (i.e., /v ʃ θ ð/) in the subset training group improved significantly in the perception posttest when compared to the perception pretest, whereas none of the scores of difficult trained onsets in the fullset training group improved significantly in the perception posttest when compared to the perception pretest. This is not surprising, since the listeners in the onset subset group were trained with only 4 difficult segments (i.e., /v ʃ θ ð/), while the listeners in the onset fullset group were trained with both easy and difficult 16 total (i.e., /v ʃ θ ð b d g k l p r s t w z tʃ/).

Nevertheless, with the same number of training sessions (i.e., seven training sessions), the onset fullset perception training appears to be more effective than the onset subset perception training. As shown in Tables 4-5 to 4-8 that after going through the seven training sessions, Thai learners of the fullset group improved more onset perception abilities than those of the subset group training. The scores of 10 onsets (i.e., /b g k l p r t w z tʃ/) in the onset fullset training group improved significantly in the perception posttest when compared to their scores in the perception pretest. While the scores of only 2 onsets (i.e., /v p/) in the onset subset training group improved significantly in the perception posttest when being compared to their scores in the perception pretest.

Furthermore, the score of 4 untrained onsets (i.e., /d s w z/) in the onset subset training group became even lower in the perception posttest. Among those 4 untrained onsets whose scores dropped in the posttest when compared to the pretest, the scores of /w/ dropped significantly (See Table 4-8). One thing that needs mentioning here is that the sudden drop between the last training session and the posttest of the onset subset group might be due to the fact that the subset group had only a few choices of sounds to select during the training sessions, but the posttest had additional choices which were not available during the training sessions (See Figure 4-19). In sum, with the same number of training sessions the onset fullset training group improved listeners' onset perception abilities better than the onset subset training group.

2.4.3 Coda Fullset vs. Coda Subset

This section provides answer to the third question of the present study, which is "Which training set will be more effective in training the easy and difficult consonant?". The answer is that the coda subset training worked more effectively in training the difficult codas but after the training some of the untrained easy coda perception abilities dropped, while the coda fullset training worked more effectively in training when considering both the easy and the difficult vowels.

Corresponding to the patterns found in the vowel and the onset trainings, the coda subset perception training seems to be better in terms of training the difficult segments because the scores of all of 6 difficult trained codas (i.e., /b g z ʃ θ ð/) in the subset training group improved significantly in the perception posttest when compared to the perception pretest, while only 3 out of 6 of the difficult trained codas (i.e., /b g z/) in the fullset training group improved significantly in the perception posttest when compared to the perception pretest. Again, this is not surprising, since the listeners in the coda subset group were trained with only 6 difficult segments (i.e., /b g z ʃ θ ð/), whereas the listeners in the coda fullset group were trained with both easy and difficult 16 total (i.e., /b g z ʃ θ ð d f k l p r s t v tʃ/).

With the same number of training sessions (i.e., seven training sessions), the coda fullset perception training appears to be more effective than the coda subset perception training. As shown in Tables 4-9 to 4-12 that after going through the seven training sessions, Thai learners of the fullset group showed more improvement with coda perception abilities than those of the subset group training. The scores of 8 codas (i.e., /b g z d l s t tʃ/) in the coda fullset training group improved significantly in the perception posttest when compared to their scores in the perception pretest. While the scores of only 6 codas (i.e., /p g z ʃ θ ð/) in the coda subset training group improved significantly in the perception posttest when being compared to their scores in the perception pretest.

In addition, the score of 6 untrained codas (i.e., /f k l p v tʃ/) in the coda subset training group became even lower in the perception posttest. Among those 6 untrained codas whose scores dropped in the posttest when compared to the pretest, the scores of 2 untrained codas (i.e., /k v/) dropped significantly

(See Table 4-12). One thing that needs mentioning here is that the sudden drop between the last training session and the posttest of the coda subset group might be due to the fact that the subset group had only a few choices of sounds to select during the training sessions, but the posttest had additional choices which were not available during the training sessions (See Figure 4-21). In sum, with the same number of training session the coda fullset training group improved listeners' coda perception abilities better than the coda subset training group.

2.5 Generalization to New Talkers (Question 4's Answers)

This section provides answers to the last research question of this study, which is "Will L1-Thai learners of L2-English be able to generalize the training to a new talker?". The answer is that listeners in every training group (i.e., Vowel Fullset, Vowel Subset, Onset Fullset, Onset Subset, Coda Fullset, and Coda Subset) were able to generalize their trained perception abilities to the new talkers, with whom they were not trained.

That Thai listeners in the present study could generalize their perception abilities in all types of segment (i.e., vowels, onsets, and codas) and in both types of training (i.e., Fullset and Subset) to the new talkers, with whom they were not trained, indicates the effectiveness of all six trainings (i.e., the vowel fullset, the vowel subset, the onset fullset, the onset subset, the coda fullset, and the coda subset training). As pointed out in the previous literature, the generalization of the perception abilities to a new talker is one of the indicators for an effective speech perception training (Logan & Pruitt, 1995) (See page 20).

Furthermore, this implies that through the training the listeners are able to store the trained segments in their long-term memory or a high-level unit. Therefore, when they were tested with the new talkers, whose speech sounds consist of different fine acoustic, they could still recognize those segments. This suggests that those segments could access the listeners' mental representations/ long-term memory after being trained (see Andruski et al., 1994). In addition, these findings agree with the ideas of Logan & Pruitt (1995) and Jamieson & Morosan (1986, 1989) that an identification task can induce changes in listeners' phonetic categorization. This is because it facilitates the development and usage of "phonetic memory codes" rather than "low-level sensory-based information". That listeners could generalize their perception abilities to the new talkers suggests that they formed "phonetic memory codes" after being trained.

This also indicates a similar pattern between vowels and consonants (i.e., both onsets and codas). As shown in many studies, although vowels and consonants are different in terms of different combinations of features, different acoustic properties, and different degree of constriction (Mannell, 2005; McCombs, 2006; Nishi & Kewley-Port, 2007; Strange, 2007), SLA adults' perception of L2 vowels can project the patterns found with L2 consonants (Best & Tyler, 2007).

3. Vowels vs. Consonants

Although previous literature (Mannell, 2015; McCombs, 2006; Strange, 2007) pointed out numerous differences between vowels and consonants, the present study results report similar development patterns and influence of training (e.g., fullset vs. subset training effect, generalization to a new talker, etc.) in both vowels and consonants. Thus, these results agree with the point made by Best & Tyler (2007): although vowels and consonants are different, many SLA studies show that the patterns of L2 vowels perception can reflect the patterns found with L2 consonants.

To illustrate, the production and the perception mechanism proposed by Flege's SLM (1992, 1995) have been attested in both vowel and consonant studies. In other words, it is possible for ESL/EFL learners to demonstrate the similar patterns for vowel and consonant acquisition. For the acquisition of consonants, Bohn & Flege (1997) showed that the experienced German could identify the new English vowel /æ/ in a similar way as the native English listeners, while their identification of the English vowel /ɛ/, which is similar to the German vowel /ɛ ɛ:/, differed from that of the native English listeners. Likewise, although the production of the new English vowel /æ/ by the experienced German speakers did not fully match that of the native English speakers, their production did not differ significantly from that of the native English speakers in terms of either the spectral or duration.

For the acquisition of consonants, Price (1981) explained that Japanese has no /l/ phoneme and the Japanese /r/ is a voiced tip-alveolar flap. Therefore, based on the SLM model, English /ɹ/ and /l/ are considered a new-category sound by Japanese speakers. MacKain, Best, & Strange (1981) showed that the abilities to perceive English /ɹ/ and /l/ of the Japanese subjects with a lot of conversational experience in English closely resembled those of the native English subjects. However, that was not the case for the Japanese subjects without such experience. In conclusion, corresponding with Best & Tyler's (2007) claim, the findings from Bohn & Flege (1997) suggest that it is easier for adult L2 learners to acquire a new-category vowel, in this case English /æ/. The similar pattern was found with adults L2 learners acquiring a new-category consonant (i.e., English /ɹ/ and /l/) in MacKain et al. (1981).

4. Other Interesting Findings

Thai listeners' perception abilities of the vowels /ɑ/ and the onsets /ʃ θ ð/, which are considered the difficult segments in this study, did not improve significantly in the posttest after being trained in both types of training (i.e., Fullset and Subset). Interestingly, the subset trainings were found to be effective in training some difficult segments in this study (i.e., the vowels /ʌ ɔ/, the onset /v/, and the codas /ʃ θ ð/).

The vowel /ɔ/ was found to be difficult for Thai listeners in this study, whereas none of the previous literature reported this. One of the reasons might be because the previous studies examining difficult English vowel sounds by Thai learners are production studies (Richards, 1967; Tsukada, 2009; Varasarin, 2007) and a literature-synthesis/ non-experimental study (Jotikasathira, 1999). To my knowledge, the current study is the only study testing Thai EFL learners' perception of English /ɑ ɔ/ in the pretest. Therefore, it is possible that Thai listeners were confused between the vowels /ɑ ɔ/. Thai does not have the equivalent sound to English /ɔ/. Thai has a similar vowel, which is /ɔ:/, but the auditory vowel-space when pronouncing Thai /ɔ:/ is considered "low", while the auditory vowel-space when pronouncing English /ɔ/ is considered "mid". Likewise, Thai does not have the equivalent sound to English /ɑ/, and the auditory vowel-space when pronouncing English /ɑ/ is "low" (See Table 2-6, Figure 2-13, and Figure 2-14).

The onset /ʃ/ was also found to be difficult for Thai listeners in the present study. As pointed out by Jotikasathira (1999) that /ʃ/ is one of the difficult English sounds for Thai learners due to the fact that it is not present in the Thai consonant inventory. Moreover, although English /ʃ/ does not exist in Thai consonant inventory, it sounds similar to Thai /cʰ/ (See Table 2-3). As previously shown, a number of loanwords which are originally pronounced with English /ʃ/, are phonologically adapted into Thai /cʰ/ in both pronunciation and orthography, such as 'shirt' [ʃəɹt] becomes [cʰɤ:t], 'show' [ʃoʊ] becomes [cʰo:ʷ], and 'fashion' [fæʃən] becomes [fæ:cʰan] (Kenstowicz & Suchato, 2006; Rungruang, 2007). Therefore, there is a possibility that Thai listeners were interfered with the L1 sound, in this case Thai /cʰ/. According to Flege's SLM (1992), a similar-category sound takes more time for adult L2 learners to acquire than a new-category sound. Had the training time been longer, those difficult segments (i.e., the vowels /ɑ ɔ/ and the onset /ʃ/) might have been improved significantly in the posttest.

The onsets /θ ð/ were also found to be difficult for Thai listeners in the present study, since their perception abilities of those two sounds were not improved after going through seven training sessions. Both English /θ ð/ do not exist in the Thai consonant inventory (See Table 2-3). As presented in Section 4.3 from Burkardt's (2005) production study with Thai ESL learners showed that Thai learners mostly replaced the voiceless interdental fricative /θ/ with /t ð d f v/ or deleted the sound in the production task. For the voiced interdental fricative /ð/ in the same task, they tended to replace the voiced interdental fricative /ð/ with /d/, /θ/, or /t/, respectively.

When considering distribution of errors by word position, it is interesting to see that Thai ESL learners in Burkardt's (2005) study had the most difficulty in producing the voiced interdental fricative /ð/ in the word initial position, which corresponds to the findings of the recent study that Thai EFL listeners had most difficulty in perceiving the same sound in the same word position (i.e., the onset /ð/). Their perception abilities for the onset /ð/ were not improved even after going through the 7-training sessions (See Tables 4-5 and 4-6), but that was not the case for the coda /ð/ (See Table 4-10).

Burkardt (2005) reported that Thai ESL learners in his study had more difficulty in producing the voiceless interdental fricative /θ/ in the word medial position than in the word initial position as found in this study. Had the current study tested and trained the English /θ/ in the word medial position, similar results might have been drawn. Thus, more studies will be needed to account for this.

Based on the observations from the findings of Burkardt's (2005) study and the current study, what seems to account for the difficulty in perceiving the onset /θ ð/ is a kind of “discriminative failure” (see also Flege, 1995) of the two sounds (i.e., the onsets /θ/ and /ð/) in the word initial position. To illustrate, it is possible that Thai learners heard the onset /θ/ as /t/, /ð/, /d/, /f/, or /v/ and heard the onset /ð/ as /d/, /θ/, or /t/. Flege (1995) showed that native speakers of Italian erred in producing /ð/ and /θ/. The two sounds were usually produced by those speakers as /d/ and /t/, respectively. He contended that this phenomenon was due to perceptual factors, such as native speakers of Italian tending to hear word-initial English /ð/ as /d/. Another possibility is that Thai EFL listeners simply confused the onsets /θ ð/ with the sounds reported in Burkardt (2005) (i.e., /t ð d f v/). The findings from Burkardt (2005) and the current study also suggest the relationship between production and perception of the L2 sounds.

In addition, the fact that the results of the present study correspond with the results from the previous studies (Nishi and Kewley-Port’s, 2007, 2008) suggests that the training set technique works well in both ESL and EFL contexts, although those two contexts are different in many aspects, demonstrated in the previous studies that the limited amount of L2 input, lack of specific training on production and perception, and accented L2 input in the EFL context hinder the attainment of the native-like production and perception (Bongaerts, 1999; Bongaerts et al., 1997; Cortés, 2002; Elliott, 1995a, 1995b; Flege, 1991; Fullana, 2006; García-Lecumberri & Gallardo, 2003; Moyer, 1999; Rallo, 2003; Singleton, 1995)

5. Implications

5.1 Speech Perception Trainings

Firstly, the results of the recent study suggest that the factors, which have been found to promote speech perception training in the previous literature: intensive laboratory training, highly variable naturally produced stimului (HVNP), an identification task for training sessions, subject-controlled stimulus presentations, immediate feedback, long-term training, (Lively et al., 1993; Logan et al., 1991; Logan and Pruitt, 1995; Nishi and Kewley-Port, 2007, 2008; Pruitt et al., 2006; Strange, 1992) (See Table 2-1), work effectively with the training sets adopted by and adjusted from Nishi and Kewley-Port (2007) regardless of the type of training (e.g., Fullset vs. Subset) and the phoneme types being trained (i.e., vowels and consonants).

As shown in the pooled scores of segment level analysis, both the fullset and the subset training groups improved significantly after going through the seven training sessions and the posttest (See Figures 4-1 to 4-3), although the perception abilities of the fullset group improved more than those of the subset groups (See Tables 4-1 to 4-12). Also, listeners in every training group (i.e., the vowel fullset, the vowel subset, the onset fullset, the onset subset, the coda fullset, and the coda subset) were able to generalize their trained perception abilities to the new talkers (See Figures 4-22 to 4-27).

Secondly, the results also suggest that with the same number of sessions, the fullset training technique, with incorporating those factors previously mentioned, were found to be more effective in training vowels for Thai EFL learners than the subset training technique. This strengthens the findings of Nishi and Kewley-Port (2007, 2008) that the fullset training works well regardless of listeners' L1. Moreover, with the same amount of time, the results of the present study suggest that the fullset training, with those factors incorporated, also works more effectively in training consonants (i.e., both onsets and codas) than the subset training. Thirdly, generalization to a new talker should be achieved to assure the effectiveness of the training.

Last but not least, although it has been reported in the previous literature that 6 to 45 training sessions is considered as a long-term training (Yamada, 1993), our results show that at the single segment analysis level Thai listeners' perception abilities of the vowels /ɑ/ and the onsets /ʃ θ ð / did not improve after being trained in the 7-training sessions in both types of trainings (i.e., Fullset and Subset) (See Tables 4-1 to 4-2 and 4-5 to 4-6). This, therefore, suggests that the training set techniques, which incorporates those factors mentioned previously, may require more than seven training sessions in order to improve certain difficult segments (e.g., the vowel /ɑ/ and the onsets /ʃ θ ð/).

5.2 Pedagogical Implications

Since the results from the recent study show that the fullset training work more effectively than the subset training in training both types of phonemes (i.e., vowels and consonants) and in both ESL (Nishi & Kewley-Port, 2007, 2008) and EFL contexts, a unit or exercises in a commercial textbook and a classroom lesson plan for teaching ESL/ EFL learners should not focus only on difficult sounds. Rather those commercial textbook exercises, lesson plans and classroom activities should incorporate both easy and difficult sounds.

6. Directions for the Future Study

The production part will be reported in a separated study to see whether Thai listeners will be able to transfer their perception abilities being trained in the recent study to the production abilities or not. As mentioned previously, some linguists point out a linkage or relationship between the production and the perception mechanism (Liberman & Mattingly, 1985, 1989; Best, 1984, 1993, 1994a, 1994b; Fowler, 1986, 1989, 1991; Studdert-Kennedy, 1985, 1986, 1989, 1991). Moreover, Bradlow et al. (1997) suggested that perception training alone can benefit production abilities of L2 segments. Lambacher, Martens, Kakehi, Marasinghe, & Molholt (2005) also showed that the perceptual training had a positive effect on the production of the target segments.

Furthermore, Nishi & Kewley-Port (2007) reported that both the fullset and the subset training groups maintained their improved perception abilities of the trained vowels for three months after the completion of the training, however the untrained vowels of the subset group never improved. Therefore, it will be interesting to see if long-term retention can be maintained when training speech perception to Thai learners, since the recent study does not address this issue yet due to the time constraints.

Besides, the previous studies (Nishi & Kewley-Port, 2007, 2008) and the current study have included only nine English monophthongs. Therefore, it would be interesting to see: 1) whether the training set technique will function effectively in training English diphthongs and 2) which type of training (i.e., the fullset and the subset trainings) functions more effectively in training English diphthongs, since diphthongs differ acoustically from monophthongs in terms of formant patterns and duration (Fox & Jacewicz, 2009; Hillenbrand, Getty, Clark, & Wheeler, 1995).

In addition, since the current study has shown that the training set technique also works with training English consonant in initial and final positions, it will be interesting to conduct the training set technique in training English consonant clusters in initial and in final positions. As shown in Table 2-5, Thai does not allow a consonant cluster in the coda but Thai is rich with consonant clusters in the onset. Hence, many possibilities can be predicted to see: 1) whether the training set technique will work effectively in training consonant clusters, 2) which type of training works more effectively in training consonant clusters between the fullset and the subset trainings, and 3) whether the results drawn from the initial cluster training and the final cluster training are similar.

Chapter 6

Conclusion

Chapter 1 showed that listening comprehension and skills play a crucial role in assuring ESL and EFL learners' academic and communication success. There are many studies that propose models or elements to help ESL and EFL learners develop their listening skills. The human speech perception mechanisms consist of two main processes (i.e., low-level and high-level units) and these two processes have been proved to work hand in hand when mapping lower-level fine acoustic details to higher-level mental representations (e.g., Anderson, 1983, 1995; Andruski et al., 1994; Chen, 2005; Clark & Clark, 1977; Cluff & Luce, 1990; Field, 2003; Fowler, 1986, 1990a, 1990b; Fowler & Rosenblum, 1990, 1991; Goh, 2000; Luce, Pisoni & Goldinger, 1990; Nunan, 1998; Palmeri, Goldinger, & Pisoni, 1993; Saricoban, 1999; Wilson, 2003). In other words, neither level can be separated from the other. And a lower-level element is very important because it helps listeners access higher-level information effectively.

Therefore, much research has been conducted to find optimal ways to train ESL and EFL listeners' speech perception. This research employed many factors, which have been proven to be effective in training speech perception in many studies. These factors include intensive laboratory training, highly variable naturally produced stimuli (HVNP), an identification task for training sessions, subject-controlled stimulus presentations, immediate feedback, and long-term training (Lively et al., 1993; Logan et al., 1991; Logan & Pruitt, 1995; Nishi & Kewley-Port, 2007, 2008; Pruitt et al., 2006; Strange, 1992).

Furthermore, Nishi & Kewley-Port (2007) also found that these factors work more effectively when they are incorporated into training sets. Nishi & Kewley-Port (2008) found that their training sets worked well regardless of listeners' L1 (e.g., Japanese and Korean). Therefore, the similar training sets (i.e., Fullset and Subset) were adopted, adjusted, and conducted with Thai EFL learners that had low-intermediate English language proficiency. The results of this study correspond with those in previous studies in both levels of analysis: the analysis of pooled scores of every segment and the individual segment analysis. For the analyses of the pooled scores of every segment, the vowel fullset training appeared to increase learners' vowel perception abilities better than the vowel subset training. The individual segment analyses revealed that with the same amount of training time (i.e., seven training sessions), the vowel fullset training could improve more number of vowels in learners' vowel perception abilities than the vowel subset training.

This study, moreover, incorporates consonants within two phonological environments (i.e., onsets and codas) while adopting the same training techniques (i.e., Onset Fullset, Onset Subset, Coda Fullset, and Coda Subset) in order to see if such techniques, when being used to train consonants, would provide a similar pattern as found with training vowels. That is, the fullset training works more effectively in training segments. Interestingly, the results show similar patterns in two different levels of analysis: the analysis of pooled scores of every segment and the individual segment analyses.

The analysis of pooled scores of every segment shows that both the onset and the coda training developed similar patterns to those of the vowel trainings. The onset fullset and the coda fullset training work more effectively than the onset subset and the coda subset training. Nonetheless, at this level of analysis, it appears that the subset training works most effectively in training codas among three different types of segments (i.e., vowels, onsets, and codas), although it is less effective than the fullset training.

The individual segment analyses also show that both the onset and the coda training drew similar patterns to those of the vowel training. The onset fullset and the coda fullset training also work more effectively than the onset subset and the coda subset training. This level of analysis reveals that with the same number of training sessions (i.e., seven training sessions), the onset fullset and the coda fullset training could improve a greater number of onsets and codas in learners' perception abilities than the onset subset and the coda subset training. Importantly, the fullset training is better than the subset training because the performance of untrained segments decreased due to the subset training – this is the common observation throughout the different training groups (i.e., vowels, onsets, and codas).

In summary, at the level of analysis of pooled scores for every segment, the fullset training works more effectively in training vowels, onsets, and codas than the subset training. And the subset training works most effectively in training codas among three different phonemes (i.e., vowels, onsets, and codas). At the level of segment analysis, with the same number of sessions (i.e., seven training sessions), the fullset training works more effectively in training vowels, onsets, and codas than the subset training, although the subset training works better when considering only difficult-segment training.

Likewise, Thai EFL learners in both vowel and consonant (i.e., onsets and codas) training groups could generalize their perception abilities to the new talkers, with whom they were not trained. This not only shows that all six training sets (i.e., the vowel fullset, the vowel subset, the onset fullest, the onset subset, the coda fullset, and the coda subset trainings) in the current study are effective, but also shows a similar pattern between vowels and consonants (i.e., both onsets and codas) similar to the case of the training patterns discussed previously. Importantly, this also suggests that through the perception training, Thai EFL learners are able to conceptualize the trained segments into their mental representations or store them in long-term memory. This implies that the changing of their phonetic categories was induced.

The results of the present study suggest that the training set technique works well in both ESL and EFL contexts. There is also a relationship between the acquisition of L2 vowels and consonants to some extent, although vowels and consonants are different in many aspects (Best & Tyler, 2007; Bohn & Flege, 1997; MacKain, Best, & Strange, 1981). The results also suggest the linkage between production and perception (Burkardt, 2005). Furthermore, when designing a lesson plan, classroom activity, unit or exercise in a commercial textbook, attention should not only be paid to difficult sounds but also easy sounds.

Lastly, the generalization of the perception abilities trained in this study to the production abilities will be presented in a separate study. This study leaves some room for future studies to explore the training sets technique with other aspects, such as long-term retention effects with learners of different L1s and training English diphthongs and consonant clusters.

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APPENDICES

Appendix A: Stimuli List

Table A-1: Vowel Fullset and Vowel Subset Stimuli List

Vowel (RW)(C_1VC_2) Fullset/ Subset (Frequency of RW; Familiarization of RW)	**Vowel (NSW)($C_1VC_{2ə}$) Fullset/ Subset**
deep (109; 7) (familiarization task) seat (54; 7) (familiarization task) beat (68; 7) feet (N/A) keep (264; 7) meet (N/A) peak (18; 7) seek (69; 6.9)	beeba /bibə/ beepa /bipə/ deeda /didə/ deeta /ditə/ geega /gigə/ geeka /gikə/
fit (75; 7) (familiarization task) kick (16; 7) (familiarization task) bit (101; 7) kit (2; 6.75) pick (55; 7) pit (14; 7) sit (67; 7) tip (22; 6.9)	biba /bɪbə/ bipa /bɪpə/ dida /dɪdə/ dita /dɪtə/ giga /gɪgə/ gika /gɪkə/
boot (familiarization task) (1; 7) mood (37; 7) (familiarization task) dude (1; 6.9) food (147; 7) loop (21; 6.9) soup (16; 7) suit (48; 7) tube (31; 7)	bouba /bubə/ boupa /bupə/ douda /dudə/ douta /dutə/ gouga /gugə/ gouka /gukə/
hook (5; 6.75) (familiarization task) look (399; 7) (familiarization task) book (193; 6.9) cook (47; 7) hood (7; 6.75) put (437; 7) took (426; 7) wood (2,769; 7)	booba /bʊbə/ boopa /bʊpə/ dooda /dʊdə/ doota /dʊtə/ googa /gʊgə/ gooka /gʊkə/

Vowel (RW)(C_1VC_2) **Fullset/ Subset** **(Frequency of RW;** **Familiarization of RW)**	**Vowel (NSW)($C_1VC_{2ə}$)** **Fullset/ Subset**
neck (81; 7) (familiarization task) net (34; 6.9) (familiarization task) bet (20; 7) deck (23; 7) get (750; 7) met (132; 6.8) pet (8; 7) set (414; 7)	 beba /bɛbə/ bepa /bɛpə/ deda /dɛdə/ deta /dɛtə/ gega /gɛgə/ geka /gɛkə/
lot (127; 7) (familiarization task) pot (28; 7) (familiarization task) cot (1; 7) dot (13; 7) jot (1; 6.1) knock (15; 7) sock (4; 7) top (204; 7)	 boba /bɑbə/ bopa /bɑpə/ doda /dɑdə/ dota /dɑtə/ goga /gɑgə/ goka /gɑkə/
but (4;393; 7) (familiarization task) duck (9; 6.7) (familiarization task) buck (20; 7) cut (192; 7) hut (13; 7) luck (47; 7) mud (32; 7) nut (15; 7)	 buba /bʌbə/ bupa /bʌpə/ duda /dʌdə/ duta /dʌtə/ guga /dʌgə/ guka /gʌkə/
cat (23; 7) (familiarization task) sack (N/A) (familiarization task) back (967; 7) bat (18; 7) cap (27; 7) hat (56; 7) fat (60; 7) mat (8; 7)	 baba /bæbə/ bapa /bæpə/ dada /dædə/ data /dætə/ gaga /gægə/ gaka /gækə/

Vowel (RW)(C_1VC_2) Fullset/ Subset (Frequency of RW; Familiarization of RW)	Vowel (NSW)($C_1VC_{2ə}$) Fullset/ Subset
dog (75; 7) (familiarization task) long (755; 7) (familiarization task) bought (56; 7) fought (46; 7) log (11; 6.7) loss (86; 7) song (70; 7) taught (66; 7)	 bauba /bɔbə/ baupa /bɔpə/ dauda /dɔdə/ dauta /dɔtə/ gauga /gɔgə/ gauka /gɔkə/

Table A-2: Onset Fullset and Onset Subset Stimuli List

Onset (RW)(CVC) **Fullset/ Subset** **(Frequency of RW;** **Familiarization of RW)**	**Onset (NSW)(CVC)** **Fullset/ Subset**
than (1,789; 4.75) (familiarization task) them (1,789; 7) (familiarization task) that (10,595; 6.41) then (1,377; 6.66) this (5,146; 7) those (850; 6.5)	thum /ðʊm/ thene /ði:n/ thes /ðɛs/ thoat /ðoʊt/
dad (15; 7) (familiarization task) deep (109;7) (familiarization task) dam (39;7) dean (40; 6.91) dim (19; 7) dot (13;7)	dipe /dɑɪp/ doak /doʊk/ dum /dʊm/ dos /dɔs/
thin (92; 7) (familiarization task) thing (333; 7) (familiarization task) theme (55;6.83) thick (67; 7) thief (8; 7) thought (515; 7)	thak /θæk/ thout /θɑʊt/ thoos /θus/ thoap /θoʊp/
team (83; 7) (familiarization task) tip (22; 6.9) (familiarization task) talk (154;7) tan (9; 7) tap (18; 6.5) top (204; 7)	tun /t^{h}ʊn/ touk /t^{h}ɑʊk/ toik /t^{h}ɔɪk/ teep /t^{h}i:p/
van (32; 7) (familiarization task) voice (226; 7) (familiarization task) vain (35; 7) vat (1; 5.41) void (10; 6.9) vote (75; 7)	vak /væk/ vop /vɔp/ vem /vɛm/ vees /vi:s/

Onset (RW)(CVC) Fullset/ Subset (Frequency of RW; Familiarization of RW)	**Onset (NSW)(CVC) Fullset/ Subset**
wine (72; 7) (familiarization task) wit (20; 6.91) (familiarization task) win (55; 7) wing (18; 6.9) wipe (10; 7) wish (110; 6.91)	wam /wæm/ wout /wɑʊt/ woam /woʊm/ wung /wʊŋ/
read (178; 6.8) (familiarization task) right (727; 7) (familiarization task) rain (80; 7) rat (6; 7) run (212; 7) rice (33; 7)	ren /ɹɛn/ reen /ɹiːn/ roit /ɹɔɪt/ roon /ɹun/
lead (261; 7) (familiarization task) lap (19; 7) (familiarization task) leap (14; 6.83) lock (N/A) loop (21; 6.91) luck (47; 7)	lat /læt/ lep /lɛp/ lin /lɪn/ lun /lʊn/
Zen (26; 2.41) (familiarization task) zip (N/A) (familiarization task) zap (N/A) zeal (8; 5.25) zone (N/A) zoom (N/A)	zan /zæn/ zawn /zɔːn/ zem /zɛm/ zoat /zoʊt/
sick (51; 7) (familiarization task) son (278; 7) (familiarization task) sat (150; 7) seat (54; 7) soon (199; 7) some (1,662; 7)	saip /seɪp/ seef /sif/ soit /sɔɪt/ soong /sʊŋ/

Onset (RW)(CVC) Fullset/ Subset (Frequency of RW; Familiarization of RW)	Onset (NSW)(CVC) Fullset/ Subset
cheap (24; 7) (familiarization task) check (88; 7) (familiarization task) cheek (20; 7) chin (27; 7) chip (17; 6.9) choice (113; 6.9)	chim /tʃɪm/ chet /tʃɛt/ choam /tʃoʊm/ choit /tʃɔɪt/
shape (85; 7) (familiarization task) sheet (45; 7) (familiarization task) shake (17; 7) shine (5; 7) shock (31; 7) shop (63; 7)	shait /ʃeɪt/ shap /ʃæp/ shem /ʃɛm/ shoon /ʃun/
bit (101; 7) (familiarization task) but (4,393; 7) (familiarization task) bad (143; 7) bean (5; 7) boat (72; 7) bone (33; 7)	bim /bɪm/ bain /beɪn/ bep /bɛp/ boak /boʊk/
pin (16; 7) (familiarization task) pain (91; 6.9) (familiarization task) pat (35; 7) pen (18; 7) pick (55; 7) pot (28; 7)	paip /pʰeɪp/ pem /pʰɛm/ peem /pʰim/ pok /pʰɔk/
gap (17; 7) (familiarization task) get (750; 7) (familiarization task) gain (74; 7) gate (N/A) goat (6; 7) gone (195; 7)	geet /git/ gom /gɔm/ gep /gɛp/ goam /goʊm/

Onset (RW)(CVC) Fullset/ Subset (Frequency of RW; Familiarization of RW)	**Onset (NSW)(CVC) Fullset/ Subset**
kick (familiarization task) (16; 7) kid (familiarization task) (61; 7) keep (264; 7) kite (1; 7) kin (2; 6.75) kiss (17; 7)	ket /k^hɛt/ koom /k^hum/ keef /k^hif/ koos /k^hus/

Table A-3: Coda Fullset and Coda Subset Stimuli List

Coda (RW)(CVC) Fullset/ Subset (Frequency of RW; Familiarization of RW)	**Coda (NSW)(CVC) Fullset/ Subset**
breathe (7; 6.75) (familiarization task) (CCVC) bathe (4; 6.54) (familiarization task) lathe (1; 4.33) loathe (1; 6.41) teethe (1; 5.3) writhe (2; 6.41)	nithe /nɪð/ loothe /luð/ mothe /moʊð/ pathe /pæð/
bed (127; 7) (familiarization task) sad (35; 7) (familiarization task) bad (143; 7) kid (61; 7) nod (12; 7) made (1,156; 7)	nad /næd/ pood /pud/ keed /ki:d/ ked /kɛd/
bath (26; 7) (familiarization task) cloth (43; 7) (familiarization task) both (730; 7) faith (111; 7) math (4; 7) south (240; 7)	paith /peɪθ/ nath /næθ/ soath /soʊθ/ teth /tɛθ/
cat (23; 7) (familiarization task) sit (67; 7) (familiarization task) coat (43;7) meet pot (28; 7) set (414; 7)	doit /dɔɪt/ dat /dæt/ ket /kɛt/ nout /nɑʊt/
cave (9; 7) (familiarization task) love (232; 6.66) (familiarization task) dove (4; 7) give (391; 7) save (62; 7) wave (N/A)	bav /bɑv/ dov /dɔv/ kav /kæv/ poov /puv/

Coda (RW)(CVC) Fullset/ Subset (Frequency of RW; Familiarization of RW)	**Coda (NSW)(CVC) Fullset/ Subset**
beef (32; 7) (familiarization task) half (275; 7) (familiarization task) leaf (12; 7) loaf (4; 7) puff (1; 6.8) cuff (1; 6.25)	kef /kɛf/ laif /leɪf/ nof /nɔf/ paff /pæf/
care (162; 6.9) (familiarization task) poor (124; 7) (familiarization task) car (274; 7) more (N/A) pair (58; 7) tour (43; 7)	jor /jɔɹ/ kir /k^{h}iɹ/ nar /nɑɹ/ sair /sæɹ/
feel (216; 7) (familiarization task) tall (55; 7) (familiarization task) bill (143; 7) call (188; 7) pool (111; 7) sail (56; 7)	pell /pɛl/ kail /keɪl/ noll /nɔl/ sool /sul/
jazz (99; 7) (familiarization task) quiz (2; 7) (familiarization task) /kwɪz/ (CCVC) biz (N/A) buzz (13; 7) cloze (N/A) fizz (8; 5.25)	lazz /læz/ maiz /meɪz/ paz /pɑz/ pez /pɛz/
boss (20; 7) (familiarization task) bus (35; 7) (familiarization task) nice (N/A) mouse (10; 7) mice (10; 7) pass (89; 7)	boose /bus/ dass /dæs/ foos /fus/ foas /foʊs/

Coda (RW)(CVC) Fullset/ Subset (Frequency of RW; Familiarization of RW)	**Coda (NSW)(CVC) Fullset/ Subset**
touch (87; 7) (familiarization task) which (3,562; 6.8) (familiarization task) batch (5; 6.66) catch (43; 7) much (937; 7) teach (41; 7)	boich /bɔɪtʃ/ datch /dætʃ/ metch /mɛtʃ/ toach /toʊtʃ/
fish (35; 7) (familiarization task) push (37; 6.9) (familiarization task) cash (N/A) dish (16; 7) rush (20; 7) wash (37; 7)	poosh /puʃ/ kash /kɑʃ/ moish /mɔɪʃ/ taish /teɪʃ/
mob (10; 7) (familiarization task) pub (1; 6.6) (familiarization task) job (238; 7) sub (5; 7) tube (31; 7) web (6; 7)	doob /dub/ moob /mub/ teb /tɛb/ seeb /sib/
lap (19; 7) (familiarization task) map (familiarization task)(13; 7) cap (27; 7) hope (178; 6.91) tape (35; 7) top (204; 7)	dop /dɔp/ joap /joʊp/ mep /mɛp/ koop /kup/
leg (58; 7) (familiarization task) log (11; 6.72) (familiarization task) big (360; 6.9) dog (75; 7) hug (3; 7) tag (5; 7)	daig /deɪg/ meeg /mi:g/ soog /sug/ teeg /ti:g/

Coda (RW)(CVC) Fullset/ Subset (Frequency of RW; Familiarization of RW)	Coda (NSW)(CVC) Fullset/ Subset
pack (25; 7) (familiarization task) sack (N/A) (familiarization task) back (967; 7) lake (54; 7) leak (2; 6.75) talk (154; 7)	 dak /dæk/ fook /fuk/ moak /moʊk/ tek /tɛk/

Appendix B: The Scores of 9 Learners in the Pretest and the Posttest Perception and the 7-session Vowel Fullset Training

Table B-1: The Scores of /ɪ/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Vowel Fullset Training

Vowel Fullset											
ɪ											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	33.33	45.83	62.50	62.50	62.50	41.67	37.50	4.17	79.17	429.17	47.69
Training 1	54.17	25.00	37.50	37.50	54.17	8.33	16.67	4.17	33.33	270.84	30.09
Training 2	70.83	16.67	70.83	45.83	41.67	29.17	29.17	25.00	45.83	375.00	41.67
Training 3	58.33	25.00	58.33	70.83	50.00	29.17	41.67	50.00	54.17	437.50	48.61
Training 4	54.17	20.83	66.67	87.50	50.00	33.33	33.33	70.83	66.67	483.33	53.70
Training 5	58.33	16.67	58.33	79.17	45.83	8.33	41.67	50.00	62.50	420.83	46.76
Training 6	58.33	16.67	83.33	75.00	41.67	8.33	33.33	4.17	50.00	370.83	41.20
Training 7	62.50	12.50	87.50	70.83	54.17	20.83	33.33	58.33	66.67	466.66	51.85
Posttest Perception	79.17	25.00	87.50	95.83	79.17	58.33	62.50	58.33	87.50	633.33	70.37

Table B-2: The Scores of /i/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Vowel Fullset Training

Vowel Fullset											
i											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	54.17	29.17	70.83	50.00	79.17	37.50	70.83	91.67	66.67	550.01	61.11
Training 1	91.67	37.50	91.67	70.83	91.67	75.00	58.33	91.67	54.17	662.51	73.61
Training 2	91.67	41.67	83.33	83.33	91.67	75.00	87.50	95.83	66.67	716.67	79.63
Training 3	91.67	37.50	91.67	87.50	87.50	95.83	79.17	95.83	79.17	745.84	82.87
Training 4	91.67	37.50	91.67	83.33	95.83	100	83.33	95.83	75.00	754.16	83.80
Training 5	95.83	54.17	100	91.67	91.67	100	95.83	91.67	79.17	800.01	88.89
Training 6	95.83	41.67	95.83	79.17	95.83	100	87.50	8.33	83.33	687.49	76.39
Training 7	100	45.83	91.67	95.83	100.00	95.83	95.83	95.83	75.00	795.82	88.42
Posttest Perception	79.17	37.50	79.17	79.17	100	87.50	79.17	95.83	66.67	704.18	78.24

Table B-3: The Scores of /ʊ/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Vowel Fullset Training

Vowel Fullset											
ʊ											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	45.83	20.83	66.67	25.00	50.00	45.83	45.83	33.33	37.50	370.82	41.20
Training 1	62.50	16.67	54.17	33.33	12.50	29.17	37.50	16.67	41.67	304.18	33.80
Training 2	66.67	8.33	70.83	33.33	12.50	25.00	58.33	12.50	33.33	320.82	35.65
Training 3	79.17	4.17	83.33	62.50	37.50	20.83	25.00	8.33	50.00	370.83	41.20
Training 4	91.67	12.50	79.17	87.50	50.00	8.33	16.67	20.83	54.17	420.84	46.76
Training 5	79.17	0.00	70.83	75.00	37.50	16.67	20.83	12.50	45.83	358.33	39.81
Training 6	75.00	12.50	70.83	66.67	37.50	16.67	12.50	25.00	33.33	350.00	38.89
Training 7	79.17	0.00	58.33	75.00	50.00	25.00	12.50	0.00	25.00	325.00	36.11
Posttest Perception	70.83	4.17	87.50	75.00	50.00	45.83	50.00	33.33	66.67	483.33	53.70

Table B-4: The Scores of /u/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Vowel Fullset Training

Vowel Fullset											
u											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	54.17	37.50	79.17	45.83	45.83	70.83	58.33	70.83	70.83	533.32	59.26
Training 1	66.67	37.50	95.83	70.83	62.50	66.67	45.83	66.67	66.67	579.17	64.35
Training 2	70.83	29.17	91.67	83.33	66.67	79.17	25.00	62.50	91.67	600.01	66.67
Training 3	70.83	50.00	91.67	79.17	66.67	83.33	66.67	58.33	83.33	650.00	72.22
Training 4	66.67	62.50	87.50	87.50	75.00	83.33	66.67	66.67	87.50	683.34	75.93
Training 5	66.67	75.00	95.83	70.83	70.83	100.00	83.33	62.50	91.67	716.66	79.63
Training 6	66.67	91.67	87.50	83.33	70.83	95.83	87.50	25.00	91.67	700.00	77.78
Training 7	75.00	100	87.50	79.17	83.33	100	91.67	75.00	87.50	779.17	86.57
Posttest Perception	83.33	83.33	83.33	83.33	79.17	83.33	87.50	83.33	83.33	749.98	83.33

Table B-5: The Scores of /ɛ/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Vowel Fullset Training

Vowel Fullset											
ɛ											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	33.33	41.67	79.17	62.50	45.83	25.00	58.33	33.33	20.83	399.99	44.44
Training 1	25.00	29.17	50.00	62.50	41.67	20.83	33.33	62.50	25.00	350.00	38.89
Training 2	29.17	50.00	75.00	66.67	37.50	4.17	37.50	83.33	20.83	404.17	44.91
Training 3	41.67	37.50	66.67	62.50	41.67	25.00	20.83	87.50	20.83	404.17	44.91
Training 4	62.50	54.17	66.67	33.33	54.17	25.00	33.33	83.33	58.33	470.83	52.31
Training 5	83.33	45.83	62.50	45.83	37.50	20.83	45.83	95.83	58.33	495.81	55.09
Training 6	62.50	50.00	66.67	58.33	54.17	16.67	33.33	12.50	54.17	408.34	45.37
Training 7	62.50	62.50	62.50	62.50	58.33	33.33	37.50	75.00	79.17	533.33	59.26
Posttest Perception	54.17	70.83	91.67	79.17	66.67	54.17	70.83	70.83	79.17	637.51	70.83

Table B-6: The Scores of /ɑ/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Vowel Fullset Training

Vowel Fullset											
ɑ											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	20.83	4.17	25.00	0.00	0.00	0.00	0.00	4.17	4.17	58.34	6.48
Training 1	29.17	8.33	70.83	0.00	16.67	29.17	45.83	37.50	8.33	245.83	27.31
Training 2	20.83	12.50	50.00	29.17	16.67	25.00	58.33	41.67	4.17	258.34	28.70
Training 3	20.83	33.33	58.33	62.50	20.83	16.67	50.00	50.00	0.00	312.49	34.72
Training 4	25.00	25.00	75.00	70.83	16.67	8.33	54.17	58.33	8.33	341.66	37.96
Training 5	29.17	62.50	83.33	83.33	16.67	33.33	58.33	41.67	4.17	412.50	45.83
Training 6	29.17	20.83	66.67	79.17	12.50	20.83	70.83	20.83	8.33	329.16	36.57
Training 7	29.17	25.00	83.33	70.83	12.50	16.67	75.00	37.50	20.83	370.83	41.20
Posttest Perception	4.17	16.67	70.83	75.00	12.50	8.33	54.17	12.50	0.00	254.17	28.24

Table B-7: The Scores of /ʌ/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Vowel Fullset Training

Vowel Fullset											
ʌ											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	50.00	41.67	29.17	12.50	29.17	58.33	62.50	70.83	25.00	379.17	42.13
Training 1	29.17	25.00	37.50	29.17	20.83	50.00	20.83	33.33	29.17	275.00	30.56
Training 2	58.33	25.00	58.33	33.33	25.00	50.00	25.00	66.67	37.50	379.16	42.13
Training 3	29.17	25.00	58.33	29.17	8.33	45.83	25.00	54.17	20.83	295.83	32.87
Training 4	62.50	41.67	62.50	41.67	33.33	50.00	41.67	58.33	45.83	437.50	48.61
Training 5	50.00	29.17	54.17	54.17	20.83	54.17	41.67	41.67	50.00	395.85	43.98
Training 6	54.17	50.00	83.33	70.83	0.00	54.17	62.50	8.33	37.50	420.83	46.76
Training 7	58.33	50.00	75.00	75.00	8.33	50.00	58.33	50.00	50.00	474.99	52.78
Posttest Perception	79.17	58.33	87.50	41.67	29.17	58.33	62.50	70.83	45.83	533.33	59.26

Table B-8: The Scores of /æ/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Vowel Fullset Training

Vowel Fullset											
æ											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	70.83	37.50	95.83	20.83	45.83	83.33	95.83	100	79.17	629.15	69.91
Training 1	83.33	12.50	70.83	66.67	25.00	75.00	29.17	79.17	12.50	454.17	50.46
Training 2	83.33	25.00	70.83	75.00	33.33	75.00	58.33	79.17	33.33	533.32	59.26
Training 3	87.50	33.33	75.00	75.00	45.83	75.00	66.67	20.83	66.67	545.83	60.65
Training 4	58.33	29.17	91.67	91.67	33.33	87.50	79.17	50.00	91.67	612.51	68.06
Training 5	62.50	37.50	91.67	100	50.00	79.17	83.33	83.33	100	687.50	76.39
Training 6	75.00	45.83	91.67	87.50	33.33	62.50	87.50	8.33	91.67	583.33	64.81
Training 7	87.50	41.67	100	91.67	41.67	79.17	91.67	79.17	91.67	704.19	78.24
Posttest Perception	100	58.33	95.83	91.67	70.83	79.17	100	100	83.33	779.16	86.57

Table B-9: The Scores of /ɔ/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Vowel Fullset Training

Vowel Fullset											
ɔ											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	83.33	58.33	54.17	29.17	33.33	45.83	45.83	16.67	20.83	387.49	43.05
Training 1	87.50	45.83	70.83	50.00	50.00	37.50	33.33	33.33	41.67	449.99	50.00
Training 2	62.50	29.17	58.33	70.83	41.67	66.67	83.33	37.50	50.00	500.00	55.56
Training 3	75.00	50.00	75.00	45.83	41.67	58.33	79.17	25.00	54.17	504.17	56.02
Training 4	79.17	50.00	87.50	79.17	33.33	66.67	79.17	58.33	66.67	600.01	66.67
Training 5	70.83	45.83	100	75.00	37.50	79.17	83.33	83.33	66.67	641.66	71.30
Training 6	62.50	62.50	100	50.00	41.67	62.50	83.33	12.50	70.83	545.83	60.65
Training 7	79.17	66.67	91.67	75.00	70.83	70.83	79.17	95.83	83.33	712.50	79.17
Posttest Perception	75.00	41.67	79.17	20.83	45.83	75.00	70.83	50.00	37.50	495.83	55.09

Table B-10: The Average Scores of 9 Learners in the Prestest and the Posttest Perception and the 7-session Vowel Fullset Training

	Vowel Fullset								
Procedure	Average Scores of 9 Learners								
	ɪ	i	ʊ	u	ɛ	ɑ	ʌ	æ	ɔ
Pretest Perception	47.69	61.11	41.20	59.26	44.44	6.48	42.13	69.91	43.05
Training 1	30.09	73.61	33.80	64.35	38.89	27.31	30.56	50.46	50.00
Training 2	41.67	79.63	35.65	66.67	44.91	28.70	42.13	59.26	55.56
Training 3	48.61	82.87	41.20	72.22	44.91	34.72	32.87	60.65	56.02
Training 4	53.70	83.80	46.76	75.93	52.31	37.96	48.61	68.06	66.67
Training 5	46.76	88.89	39.81	79.63	55.09	45.83	43.98	76.39	71.30
Training 6	41.20	76.39	38.89	77.78	45.37	36.57	46.76	64.81	60.65
Training 7	51.85	88.42	36.11	86.57	59.26	41.20	52.78	78.24	79.17
Posttest Perception	70.37	78.24	53.70	83.33	70.83	28.24	59.26	86.57	55.09

Appendix C: The Scores of 10 Learners in the Pretest and the Posttest Perception and the 7-session Vowel Subset Training

Table C-1: The Scores /ɪ/ of 10 Learners in the Pretest and the Posttest Perception Vowel Subset Training

Vowel Subset												
ɪ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	45.83	50.00	20.83	54.17	37.50	25.00	54.17	20.83	54.17	58.33	420.83	42.08
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Perception	70.83	50.00	33.33	62.50	45.83	29.17	41.67	20.83	37.50	62.50	454.16	45.42

Table C-2: The Scores /i/ of 10 Learners in the Pretest and the Posttest Perception Vowel Subset Training

Vowel Subset												
i												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	75.00	33.33	58.33	75.00	75.00	58.33	29.17	75.00	29.17	79.17	587.50	58.75
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Perception	83.33	79.17	70.83	83.33	83.33	58.33	25.00	87.50	62.50	70.83	704.15	70.42

Table C-3: The Scores /ʊ/ of 10 Learners in the Pretest and the Posttest Perception Vowel Subset Training

Vowel Subset												
ʊ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	58.33	33.33	45.83	41.67	50.00	50.00	37.50	37.50	45.83	50.00	449.99	45.00
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Perception	79.17	58.33	58.33	50.00	50.00	33.33	54.17	37.50	37.50	41.67	500	50.00

Table C-4: The Scores /u/ of 10 Learners in the Pretest and the Posttest Perception Vowel Subset Training

Vowel Subset												
u												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	70.83	41.67	45.83	66.67	54.17	79.17	54.17	87.50	79.17	62.50	641.68	64.17
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Perception	58.33	50.00	79.17	62.50	58.33	66.67	50.00	83.33	66.67	58.33	633.33	63.33

Table C-5: The Scores /ɛ/ of 10 Learners in the Pretest and the Posttest Perception Vowel Subset Training

Vowel Subset												
ɛ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	4.17	25.00	50.00	45.83	54.17	41.67	25.00	95.83	58.33	62.50	462.50	46.25
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Perception	20.83	70.83	66.67	45.83	16.67	25.00	50.00	66.67	66.67	70.83	500	50.00

Table C-6: The Scores /ɑ/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Vowel Subset Training

Vowel Subset												
ɑ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	0.00	0.00	8.33	12.50	25.00	33.33	8.33	75.00	0.00	8.33	170.82	17.08
Training 1	54.17	25.00	37.50	29.17	29.17	29.17	12.50	75.00	20.83	54.17	366.68	36.67
Training 2	37.50	54.17	66.67	45.83	70.83	29.17	20.83	79.17	37.50	45.83	487.50	48.75
Training 3	75.00	33.33	70.83	20.83	75.00	45.83	16.67	87.50	25.00	41.67	491.66	49.17
Training 4	79.17	66.67	45.83	70.83	66.67	37.50	12.50	83.33	37.50	50.00	550.00	55.00
Training 5	66.67	70.83	58.33	41.67	62.50	12.50	20.83	79.17	41.67	41.67	495.84	49.58
Training 6	79.17	62.50	70.83	37.50	70.83	20.83	54.17	83.33	58.33	54.17	591.66	59.17
Training 7	70.83	62.50	66.67	37.50	70.83	16.67	62.50	83.33	66.67	75.00	612.50	61.25
Posttest Perception	0.00	29.17	45.83	8.33	12.50	25.00	8.33	54.17	0.00	41.67	225.00	22.50

Table C-7: The Scores /ʌ/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Vowel Subset Training

Vowel Subset												
ʌ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	37.50	25.00	0.00	16.67	45.83	20.83	16.67	8.33	62.50	20.83	254.16	25.42
Training 1	58.33	41.67	45.83	50.00	79.17	66.67	37.50	54.17	41.67	66.67	541.68	54.17
Training 2	62.50	70.83	54.17	66.67	41.67	45.83	37.50	58.33	58.33	83.33	579.16	57.92
Training 3	75.00	70.83	62.50	70.83	83.33	62.50	70.83	79.17	50.00	79.17	704.16	70.42
Training 4	70.83	87.50	62.50	83.33	87.50	50.00	66.67	83.33	75.00	83.33	749.99	75.00
Training 5	37.50	91.67	79.17	87.50	75.00	66.67	79.17	70.83	58.33	91.67	737.51	73.75
Training 6	62.50	91.67	79.17	91.67	66.67	75.00	75.00	91.67	45.83	70.83	750.01	75.00
Training 7	75.00	87.50	79.17	95.83	66.67	62.50	95.83	83.33	50.00	95.83	791.66	79.17
Posttest Perception	41.67	45.83	41.67	33.33	41.67	41.67	20.83	58.33	58.33	50.00	433.33	43.33

Table C-8: The Scores /æ/ of 10 Learners in the Pretest and the Posttest Perception Vowel Subset Training

Vowel Subset												
æ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	100	58.33	45.83	100	79.17	100	41.67	100.00	62.50	66.67	754.17	75.42
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Perception	100	50.00	45.83	87.50	62.50	100.00	54.17	100	87.50	58.33	745.83	74.58

Table C-9: The Scores /ɔ/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Vowel Subset Training

Vowel Subset												
ɔ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	62.50	29.17	25.00	41.67	41.67	62.50	29.17	62.50	29.17	37.50	420.85	42.09
Training 1	41.67	66.67	37.50	54.17	66.67	37.50	79.17	62.50	41.67	58.33	545.85	54.59
Training 2	25.00	70.83	45.83	66.67	70.83	54.17	58.33	70.83	58.33	58.33	579.15	57.92
Training 3	33.33	62.50	58.33	58.33	50.00	66.67	70.83	79.17	33.33	54.17	566.66	56.67
Training 4	58.33	58.33	79.17	41.67	79.17	70.83	66.67	75.00	54.17	66.67	650.01	65.00
Training 5	54.17	91.67	70.83	70.83	91.67	58.33	70.83	79.17	41.67	70.83	700.00	70.00
Training 6	87.50	83.33	62.50	66.67	79.17	70.83	70.83	87.50	20.83	79.17	708.33	70.83
Training 7	79.17	91.67	62.50	66.67	91.67	100	79.17	75.00	33.33	83.33	762.51	76.25
Posttest Perception	62.50	70.83	50.00	54.17	54.17	100	41.67	62.50	29.17	66.67	591.68	59.17

Table C-10: The Average Scores of 10 Learners in the Pretest and the Posttest Perception and the 7-session Vowel Subset Training

Procedure	Vowel Subset								
	Average Scores of 10 Learners								
	ɪ	i	ʊ	u	ɛ	ɑ	ʌ	æ	ɔ
Pretest Perception	42.08	58.75	45.00	64.17	46.25	17.08	25.42	75.42	42.09
Training 1						36.67	54.17		54.59
Training 2						48.75	57.92		57.92
Training 3						49.17	70.42		56.67
Training 4						55.00	75.00		65.00
Training 5						49.58	73.75		70.00
Training 6						59.17	75.00		70.83
Training 7						61.25	79.17		76.25
Posttest Perception	45.42	70.42	50.00	63.33	50.00	22.50	43.33	74.58	59.17

Appendix D: The Scores of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Table D-1: The Scores of /b/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
b												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	62.50	75.00	43.75	68.75	75.00	68.75	87.50	68.75	87.50	62.50	700.00	70.00
Training 1	81.25	62.50	68.75	50.00	56.25	87.50	93.75	81.25	75.00	100	756.25	75.63
Training 2	87.50	62.50	68.75	43.75	37.50	93.75	93.75	81.25	100	93.75	762.50	76.25
Training 3	81.25	87.50	68.75	37.50	18.75	93.75	100	93.75	93.75	93.75	768.75	76.88
Training 4	93.75	81.25	87.50	43.75	37.50	93.75	100	93.75	100	93.75	825.00	82.50
Training 5	93.75	100	87.50	31.25	25.00	100	100	93.75	100	100	831.25	83.13
Training 6	100	100	87.50	50.00	37.50	93.75	100	100	93.75	100	862.50	86.25
Training 7	93.75	100	75.00	43.75	43.75	100	100	100	93.75	93.75	843.75	84.38
Posttest Per	81.25	87.50	87.50	56.25	62.50	100	93.75	87.50	87.50	100	843.75	84.38

Table D-2: The Scores of /d/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
d												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	50.00	68.75	43.75	75.00	75.00	50.00	75.00	75.00	87.50	12.50	612.50	61.25
Training 1	31.25	87.50	100	100	100	93.75	100	87.50	81.25	56.25	837.50	83.75
Training 2	56.25	100	93.75	100	100	87.50	93.75	100	87.50	56.25	875.00	87.50
Training 3	25.00	87.50	93.75	100	93.75	100	87.50	100	62.50	93.75	843.75	84.38
Training 4	18.75	87.50	93.75	100	100	100	81.25	93.75	81.25	93.75	850.00	85.00
Training 5	12.50	93.75	93.75	100	100	100	93.75	100	56.25	93.75	843.75	84.38
Training 6	25.00	100	93.75	100	100	100	87.50	100	81.25	87.50	875.00	87.50
Training 7	56.25	100	100	100	100	100	75.00	100	81.25	100	912.50	91.25
Posttest Per	50.00	81.25	93.75	81.25	100	87.50	75.00	75.00	75.00	100	818.75	81.88

Table D-3: The Scores of /g/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
g												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	75.00	93.75	37.50	87.50	100	25.00	93.75	81.25	68.75	18.75	681.25	68.13
Training 1	81.25	93.75	81.25	93.75	87.50	56.25	100	81.25	75.00	43.75	793.75	79.38
Training 2	87.50	87.50	81.25	87.50	93.75	75.00	100	81.25	81.25	56.25	831.25	83.13
Training 3	93.75	100	75.00	93.75	100	87.50	100	87.50	100	75.00	912.50	91.25
Training 4	93.75	93.75	75.00	93.75	100	81.25	100	93.75	81.25	68.75	881.25	88.13
Training 5	87.50	100	75.00	81.25	100	87.50	100	100	100	75.00	906.25	90.63
Training 6	93.75	100	75.00	93.75	87.50	81.25	100	87.50	100	87.50	906.25	90.63
Training 7	87.50	100	75.00	93.75	93.75	100	100	100	87.50	100	937.50	93.75
Posttest Per	87.50	100	75.00	87.50	93.75	87.50	100	87.50	81.25	93.75	893.75	89.38

Table D-4: The Scores of /k/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
k												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	81.25	75.00	56.25	62.50	93.75	56.25	100	100	93.75	87.50	806.25	80.63
Training 1	68.75	68.75	75.00	93.75	93.75	81.25	100	87.50	93.75	100	862.50	86.25
Training 2	93.75	93.75	93.75	100	93.75	93.75	100	100	100	93.75	962.50	96.25
Training 3	87.50	100	87.50	93.75	93.75	93.75	100	100	100	87.50	943.75	94.38
Training 4	100	100	93.75	100	100	100	100	100	100	100	993.75	99.38
Training 5	100	100	100	100	100	100	100	93.75	100	100	993.75	99.38
Training 6	93.75	100	100	100	100	100	100	100	100	100	993.75	99.38
Training 7	100	100	93.75	100	87.50	100	100	93.75	100	100	975.00	97.50
Posttest Per	100	100	100	100	100	100	100	100	100	100	1000.00	100

Table D-5: The Scores of /l/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
l												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	62.50	56.25	50.00	50.00	50.00	50.00	75.00	56.25	93.75	62.50	606.25	60.63
Training 1	50.00	62.50	43.75	56.25	37.50	62.50	75.00	43.75	100	75.00	606.25	60.63
Training 2	87.50	56.25	43.75	31.25	43.75	50.00	93.75	50.00	100	75.00	631.25	63.13
Training 3	81.25	68.75	50.00	25.00	18.75	56.25	100	56.25	100	50.00	606.25	60.63
Training 4	81.25	81.25	81.25	43.75	43.75	68.75	81.25	56.25	100	62.50	700.00	70.00
Training 5	81.25	75.00	56.25	81.25	37.50	62.50	100	50.00	100	75.00	718.75	71.88
Training 6	81.25	75.00	81.25	31.25	50.00	50.00	93.75	50.00	100	62.50	675.00	67.50
Training 7	100	68.75	75.00	43.75	43.75	56.25	100	56.25	100	50.00	693.75	69.38
Posttest Per	100	50.00	93.75	62.50	56.25	81.25	87.50	56.25	100	87.50	775.00	77.50

Table D-6: The Scores of /p/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
p												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	93.75	100	68.75	93.75	100	43.75	100	87.50	100	75.00	862.50	86.25
Training 1	100	100	62.50	100	100	81.25	100	93.75	100	93.75	931.25	93.13
Training 2	100	100	93.75	93.75	93.75	93.75	100	87.50	100	100	962.50	96.25
Training 3	100	100	87.50	100	93.75	100	100	100	100	100	981.25	98.13
Training 4	100	100	93.75	100	100	100	100	100	100	100	993.75	99.38
Training 5	100	100	100	100	100	100	100	100	100	100	1000.00	100
Training 6	93.75	100	100	100	100	100	100	100	100	100	993.75	99.38
Training 7	100	100	100	100	100	100	100	100	100	93.75	993.75	99.38
Posttest Per	100	100	100	100	100	100	100	100	100	100	1000.00	100

Table D-7: The Scores of /ɹ/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
ɹ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	81.25	56.25	68.75	81.25	56.25	18.75	81.25	75.00	100	50.00	668.75	66.88
Training 1	81.25	43.75	93.75	31.25	56.25	50.00	81.25	50.00	87.50	62.50	637.50	63.75
Training 2	68.75	62.50	87.50	50.00	62.50	68.75	100	68.75	87.50	43.75	700.00	70.00
Training 3	81.25	62.50	75.00	37.50	56.25	62.50	100	62.50	93.75	43.75	675.00	67.50
Training 4	87.50	68.75	81.25	43.75	68.75	56.25	100	75.00	93.75	56.25	731.25	73.13
Training 5	100.00	68.75	87.50	75.00	56.25	75.00	100	81.25	93.75	56.25	793.75	79.38
Training 6	93.75	56.25	93.75	87.50	75.00	75.00	100	87.50	100	56.25	825.00	82.50
Training 7	81.25	93.75	62.50	81.25	62.50	75.00	100	68.75	100	75.00	800.00	80.00
Posttest Per	93.75	68.75	100	93.75	68.75	62.50	100	81.25	100	93.75	862.50	86.25

Table D-8: The Scores of /s/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
s												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	43.75	75.00	50.00	62.50	37.50	62.50	87.50	12.50	50.00	43.75	525.00	52.50
Training 1	25.00	43.75	12.50	43.75	18.75	62.50	75.00	31.25	75.00	43.75	431.25	43.13
Training 2	43.75	75.00	37.50	87.50	56.25	68.75	50.00	50.00	87.50	50.00	606.25	60.63
Training 3	37.50	75.00	37.50	81.25	62.50	25.00	68.75	81.25	81.25	31.25	581.25	58.13
Training 4	25.00	75.00	43.75	68.75	56.25	62.50	93.75	68.75	100	37.50	631.25	63.13
Training 5	31.25	75.00	37.50	75.00	43.75	56.25	93.75	87.50	100	31.25	631.25	63.13
Training 6	18.75	81.25	31.25	81.25	62.50	37.50	100	68.75	100	37.50	618.75	61.88
Training 7	56.25	87.50	37.50	75.00	100	56.25	93.75	81.25	87.50	31.25	706.25	70.63
Posttest Per	56.25	87.50	56.25	50.00	100	37.50	75.00	81.25	81.25	31.25	656.25	65.63

Table D-9: The Scores of /t/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
t												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	68.75	81.25	62.50	75.00	87.50	37.50	100	93.75	100	75.00	781.25	78.13
Training 1	43.75	93.75	68.75	100	87.50	87.50	100	87.50	100	37.50	806.25	80.63
Training 2	93.75	100	87.50	93.75	93.75	81.25	100	87.50	93.75	68.75	900.00	90.00
Training 3	68.75	93.75	87.50	100	100	100	100	100	100	75.00	925.00	92.50
Training 4	93.75	100	87.50	100	100	93.75	100	100	100	81.25	956.25	95.63
Training 5	75.00	93.75	87.50	100	87.50	100	100	100	100	100	943.75	94.38
Training 6	87.50	100	87.50	100	100	93.75	100	100	100	93.75	962.50	96.25
Training 7	87.50	100	81.25	100	100	93.75	100	100	100	100	962.50	96.25
Posttest Per	93.75	93.75	81.25	100	100	93.75	100	100	100	87.50	950.00	95.00

Table D-10: The Scores of /v/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
v												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	43.75	56.25	12.50	43.75	56.25	25.00	56.25	12.50	18.75	37.50	362.50	36.25
Training 1	50.00	62.50	62.50	37.50	68.75	6.25	50.00	0.00	50.00	50.00	437.50	43.75
Training 2	56.25	43.75	62.50	43.75	68.75	56.25	68.75	25.00	62.50	43.75	531.25	53.13
Training 3	62.50	31.25	68.75	25.00	56.25	62.50	62.50	31.25	50.00	50.00	500.00	50.00
Training 4	81.25	25.00	81.25	18.75	62.50	68.75	75.00	50.00	50.00	56.25	568.75	56.88
Training 5	56.25	50.00	81.25	25.00	81.25	56.25	62.50	62.50	56.25	68.75	600.00	60.00
Training 6	81.25	62.50	93.75	37.50	81.25	62.50	68.75	68.75	37.50	75.00	668.75	66.88
Training 7	50.00	43.75	100	31.25	68.75	62.50	75.00	75.00	56.25	87.50	650.00	65.00
Posttest Per	75.00	37.50	56.25	12.50	50.00	37.50	62.50	31.25	56.25	75.00	493.75	49.38

Table D-11: The Scores of /w/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
w												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	50.00	31.25	18.75	68.75	68.75	12.50	75.00	81.25	37.50	62.50	506.25	50.63
Training 1	50.00	31.25	50.00	62.50	31.25	43.75	50.00	87.50	56.25	75.00	537.50	53.75
Training 2	68.75	62.50	68.75	81.25	50.00	81.25	87.50	81.25	93.75	81.25	756.25	75.63
Training 3	87.50	56.25	75.00	93.75	18.75	93.75	56.25	93.75	81.25	75.00	731.25	73.13
Training 4	75.00	50.00	75.00	87.50	37.50	68.75	75.00	93.75	93.75	75.00	731.25	73.13
Training 5	75.00	50.00	75.00	100	37.50	93.75	75.00	100	93.75	81.25	781.25	78.13
Training 6	93.75	56.25	75.00	93.75	56.25	93.75	81.25	100	87.50	68.75	806.25	80.63
Training 7	75.00	62.50	75.00	100	75.00	81.25	75.00	100	87.50	81.25	812.50	81.25
Posttest Per	75.00	56.25	75.00	87.50	87.50	56.25	87.50	93.75	62.50	56.25	737.50	73.75

Table D-12: The Scores of /z/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
z												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	62.50	50.00	25.00	31.25	25.00	56.25	25.00	50.00	75.00	56.25	456.25	45.63
Training 1	50.00	43.75	50.00	0.00	31.25	25.00	0.00	37.50	50.00	31.25	318.75	31.88
Training 2	75.00	37.50	43.75	18.75	50.00	43.75	37.50	81.25	75.00	31.25	493.75	49.38
Training 3	93.75	37.50	43.75	37.50	18.75	50.00	81.25	87.50	50.00	25.00	525.00	52.50
Training 4	68.75	56.25	18.75	18.75	25.00	56.25	75.00	93.75	56.25	6.25	475.00	47.50
Training 5	81.25	56.25	56.25	50.00	18.75	93.75	75.00	100	75.00	6.25	612.50	61.25
Training 6	81.25	68.75	50.00	37.50	50.00	81.25	68.75	100	68.75	25.00	631.25	63.13
Training 7	56.25	56.25	31.25	18.75	31.25	93.75	81.25	100	75.00	12.50	556.25	55.63
Posttest Per	81.25	68.75	43.75	31.25	31.25	50.00	81.25	93.75	75.00	50.00	606.25	60.63

Table D-13: The Scores of /tʃ/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
tʃ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	43.75	75.00	37.50	43.75	62.50	18.75	43.75	62.50	56.25	43.75	487.50	48.75
Training 1	56.25	50.00	43.75	43.75	93.75	75.00	37.50	87.50	31.25	31.25	550.00	55.00
Training 2	50.00	37.50	25.00	31.25	68.75	56.25	68.75	75.00	75.00	31.25	518.75	51.88
Training 3	68.75	62.50	43.75	37.50	87.50	81.25	56.25	93.75	75.00	56.25	662.50	66.25
Training 4	56.25	56.25	43.75	62.50	68.75	62.50	81.25	68.75	87.50	56.25	643.75	64.38
Training 5	68.75	43.75	43.75	50.00	87.50	75.00	75.00	93.75	93.75	43.75	675.00	67.50
Training 6	75.00	75.00	12.50	50.00	68.75	62.50	62.50	93.75	87.50	62.50	650.00	65.00
Training 7	50.00	62.50	37.50	75.00	75.00	56.25	93.75	100	87.50	68.75	706.25	70.63
Posttest Per	62.50	50.00	18.75	81.25	75.00	50.00	93.75	100	93.75	62.50	687.50	68.75

Table D-14: The Scores of /ʃ/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
ʃ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	37.50	25.00	18.75	50.00	25.00	37.50	75.00	18.75	12.50	25.00	325.00	32.50
Training 1	37.50	62.50	18.75	37.50	31.25	43.75	25.00	6.25	31.25	50.00	343.75	34.38
Training 2	37.50	75.00	31.25	18.75	12.50	37.50	68.75	12.50	43.75	43.75	381.25	38.13
Training 3	50.00	93.75	43.75	25.00	18.75	50.00	56.25	37.50	31.25	25.00	431.25	43.13
Training 4	81.25	93.75	25.00	18.75	31.25	31.25	43.75	43.75	43.75	56.25	468.75	46.88
Training 5	62.50	68.75	43.75	18.75	25.00	50.00	87.50	37.50	25.00	75.00	493.75	49.38
Training 6	56.25	75.00	18.75	0.00	37.50	31.25	37.50	50.00	37.50	75.00	418.75	41.88
Training 7	43.75	87.50	25.00	12.50	31.25	31.25	81.25	56.25	37.50	56.25	462.50	46.25
Posttest Per	68.75	87.50	12.50	12.50	25.00	50.00	68.75	25.00	18.75	75.00	443.75	44.38

Table D-15: The Scores of /θ/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
θ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	25.00	18.75	0.00	0.00	0.00	6.25	18.75	12.50	6.25	37.50	125.00	12.50
Training 1	37.50	0.00	12.50	6.25	0.00	0.00	43.75	6.25	0.00	37.50	143.75	14.38
Training 2	37.50	12.50	37.50	6.25	0.00	0.00	62.50	25.00	0.00	43.75	225.00	22.50
Training 3	31.25	12.50	25.00	6.25	0.00	0.00	68.75	31.25	12.50	25.00	212.50	21.25
Training 4	37.50	12.50	18.75	6.25	0.00	0.00	81.25	0.00	18.75	25.00	200.00	20.00
Training 5	56.25	6.25	37.50	0.00	0.00	0.00	93.75	12.50	25.00	25.00	256.25	25.63
Training 6	43.75	31.25	25.00	6.25	0.00	0.00	68.75	31.25	25.00	31.25	262.50	26.25
Training 7	75.00	56.25	31.25	0.00	0.00	6.25	81.25	18.75	18.75	25.00	312.50	31.25
Posttest Per	68.75	25.00	43.75	6.25	0.00	0.00	75.00	12.50	18.75	18.75	268.75	26.88

Table D-16: The Scores of /ð/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Onset Fullset												
ð												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	12.50	12.50	12.50	25.00	25.00	0.00	6.25	12.50	18.75	31.25	156.25	15.63
Training 1	31.25	0.00	18.75	12.50	6.25	6.25	6.25	25.00	0.00	31.25	137.50	13.75
Training 2	18.75	6.25	25.00	18.75	0.00	0.00	18.75	18.75	12.50	12.50	131.25	13.13
Training 3	25.00	6.25	6.25	12.50	12.50	6.25	37.50	12.50	56.25	25.00	200.00	20.00
Training 4	18.75	0.00	6.25	18.75	6.25	12.50	31.25	12.50	18.75	12.50	137.50	13.75
Training 5	18.75	6.25	6.25	12.50	0.00	6.25	37.50	12.50	43.75	25.00	168.75	16.88
Training 6	12.50	12.50	12.50	0.00	0.00	12.50	37.50	12.50	37.50	0.00	137.50	13.75
Training 7	6.25	0.00	0.00	6.25	0.00	12.50	37.50	0.00	25.00	18.75	106.25	10.63
Posttest Per	12.50	25.00	12.50	18.75	0.00	18.75	56.25	6.25	25.00	0.00	175.00	17.50

Table D-17: The Average Scores of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Fullset Training

Procedure	Onset Fullset															
	Average Scores of 10 Learners															
	b	d	g	k	l	p	ɹ	s	t	v	w	z	tʃ	ʃ	θ	ð
Pretest Perception	70.00	61.25	68.13	80.63	60.63	86.25	66.88	52.50	78.13	36.25	50.63	45.63	48.75	32.5	12.50	15.63
Training 1	75.63	83.75	79.38	86.25	60.63	93.13	63.75	43.13	80.63	43.75	53.75	31.88	55.00	34.38	14.38	13.75
Training 2	76.25	87.50	83.13	96.25	63.13	96.25	70.00	60.63	90.00	53.13	75.63	49.38	51.88	38.13	22.50	13.13
Training 3	76.88	84.38	91.25	94.38	60.63	98.13	67.50	58.13	92.50	50.00	73.13	52.50	66.25	43.13	21.25	20.00
Training 4	82.50	85.00	88.13	99.38	70.00	99.38	73.13	63.13	95.63	56.88	73.13	47.50	64.38	46.88	20.00	13.75
Training 5	83.13	84.38	90.63	99.38	71.88	100.00	79.38	63.13	94.38	60.00	78.13	61.25	67.50	49.38	25.63	16.88
Training 6	86.25	87.50	90.63	99.38	67.50	99.38	82.50	61.88	96.25	66.88	80.63	63.13	65.00	41.88	26.25	13.75
Training 7	84.38	91.25	93.75	97.50	69.38	99.38	80.00	70.63	96.25	65.00	81.25	55.63	70.63	46.25	31.25	10.63
Posttest Perception	84.38	81.88	89.38	100.00	77.50	100.00	86.25	65.63	95.00	49.38	73.75	60.63	68.75	44.38	26.88	17.50

Appendix E: The Scores of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Subset Training

Table E-1: The Scores of /b/ of 10 Learners in the Pretest and the Posttest Perception Onset Subset Training

Onset Subset												
b												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	56.25	68.75	87.50	68.75	75.00	50.00	87.50	37.50	68.75	75.00	675.00	67.50
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	50.00	68.75	87.50	56.25	56.25	75.00	68.75	81.25	50.00	81.25	675.00	67.50

Table E-2: The Scores of /d/ of 10 Learners in the Pretest and the Posttest Perception Onset Subset Training

Onset Subset												
d												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	75.00	68.75	87.50	68.75	62.50	68.75	62.50	43.75	56.25	75.00	668.75	66.88
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	56.25	68.75	75.00	43.75	50.00	62.50	43.75	62.50	56.25	75.00	593.75	59.38

Table E-3: The Scores of /g/ of 10 Learners in the Pretest and the Posttest Perception Onset Subset Training

Onset Subset												
g												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	93.75	68.75	100	81.25	75.00	81.25	62.50	62.50	93.75	68.75	787.50	78.75
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	87.50	100	100	75.00	81.25	100	75.00	87.50	75.00	87.50	868.75	86.88

Table E-4: The Scores of /k/ of 10 Learners in the Pretest and the Posttest Perception Onset Subset Training

Onset Subset												
k												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	68.75	100	87.50	100	62.50	62.50	87.50	68.75	87.50	87.50	812.50	81.25
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	93.75	100	81.25	68.75	81.25	68.75	87.50	56.25	75.00	100	812.50	81.25

Table E-5: The Scores of /l/ of 10 Learners in the Pretest and the Posttest Perception Onset Subset Training

Onset Subset												
l												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	50.00	31.25	12.50	43.75	62.50	37.50	62.50	37.50	81.25	62.50	481.25	48.13
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	37.50	62.50	37.50	50.00	56.25	31.25	68.75	68.75	75.00	56.25	543.75	54.38

Table E-6: The Scores of /p/ of 10 Learners in the Pretest and the Posttest Perception Onset Subset Training

Onset Subset												
p												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	93.75	75.00	93.75	93.75	100	87.50	87.50	50.00	100	87.50	868.75	86.88
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	93.75	93.75	100	93.75	100	100	100	87.50	93.75	100	962.50	96.25

Table E-7: The Scores of /ɹ/ of 10 Learners in the Pretest and the Posttest Perception Onset Subset Training

Onset Subset												
ɹ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	68.75	81.25	100	75.00	68.75	75.00	56.25	37.50	100	81.25	743.75	74.38
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	81.25	81.25	100	93.75	62.50	81.25	68.75	75.00	93.75	62.50	800.00	80.00

Table E-8: The Scores of /s/ of 10 Learners in the Pretest and the Posttest Perception Onset Subset Training

Onset Subset												
s												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	37.50	31.25	18.75	50.00	56.25	62.50	43.75	43.75	37.50	50.00	431.25	43.13
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	56.25	12.50	12.50	37.50	43.75	31.25	56.25	31.25	37.50	56.25	375.00	37.50

Table E-9: The Scores of /t/ of 10 Learners in the Pretest and the Posttest Perception Onset Subset Training

Onset Subset												
t												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	81.25	81.25	87.50	93.75	68.75	62.50	50.00	31.25	93.75	93.75	743.75	74.38
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	81.25	100	87.50	81.25	81.25	81.25	56.25	25.00	81.25	100	775.00	77.50

Table E-10: The Scores of /v/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Subset Training

Onset Subset												
v												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	68.75	31.25	37.50	18.75	18.75	25.00	43.75	31.25	37.50	31.25	343.75	34.38
Training 1	93.75	37.50	100	37.50	75.00	75.00	68.75	50.00	75.00	81.25	693.75	69.38
Training 2	93.75	81.25	93.75	43.75	81.25	62.50	87.50	81.25	87.50	87.50	800.00	80.00
Training 3	100	87.50	100	68.75	87.50	93.75	81.25	75.00	81.25	87.50	862.50	86.25
Training 4	93.75	81.25	100	93.75	87.50	100	81.25	81.25	56.25	93.75	868.75	86.88
Training 5	93.75	93.75	100	93.75	87.50	93.75	81.25	87.50	75.00	100	906.25	90.63
Training 6	100	93.75	100	93.75	87.50	100	75.00	93.75	93.75	100	937.50	93.75
Training 7	100	87.50	100	100	87.50	100	87.50	87.50	87.50	100	937.50	93.75
Posttest Per	62.50	50.00	75.00	62.50	43.75	68.75	62.50	93.75	68.75	75.00	662.50	66.25

Table E-11: The Scores of /w/ of 10 Learners in the Pretest and the Posttest Perception Onset Subset Training

Onset Subset												
w												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	50.00	31.25	56.25	62.50	81.25	37.50	75.00	43.75	68.75	81.25	587.50	58.75
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	50.00	18.75	75.00	31.25	62.50	25.00	56.25	18.75	37.50	50.00	425.00	42.50

Table E-12: The Scores of /z/ of 10 Learners in the Pretest and the Posttest Perception Onset Subset Training

Onset Subset												
z												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	50.00	56.25	68.75	43.75	87.50	68.75	81.25	37.50	68.75	50.00	612.50	61.25
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	75.00	75.00	43.75	50.00	68.75	56.25	43.75	56.25	50.00	50.00	568.75	56.88

Table E-13: The Scores of /tʃ/ of 10 Learners in the Pretest and the Posttest Perception Onset Subset Training

Onset Subset												
tʃ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	43.75	93.75	68.75	43.75	50.00	62.50	62.50	18.75	56.25	62.50	562.50	56.25
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	62.50	81.25	50.00	6.25	75.00	81.25	68.75	37.50	68.75	56.25	587.50	58.75

Table E-14: The Scores of /ʃ/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Subset Training

Onset Subset												
ʃ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	68.75	56.25	50.00	25.00	43.75	37.50	43.75	50.00	31.25	25.00	431.25	43.13
Training 1	100	87.50	87.50	75.00	81.25	100	93.75	62.50	100	100	887.50	88.75
Training 2	100	93.75	75.00	100	100	100	100	81.25	100	93.75	943.75	94.38
Training 3	100	100	100	100	75.00	100	81.25	93.75	100	87.50	937.50	93.75
Training 4	87.50	93.75	100	100	68.75	93.75	81.25	75.00	100	100	900.00	90.00
Training 5	81.25	81.25	93.75	100	75.00	87.50	100	87.50	100	100	906.25	90.63
Training 6	87.50	93.75	93.75	100	68.75	75.00	100	100	100	100	918.75	91.88
Training 7	81.25	100	93.75	100	75.00	87.50	100	100	100	93.75	931.25	93.13
Posttest Per	56.25	37.50	18.75	75.00	43.75	43.75	37.50	68.75	75.00	56.25	512.50	51.25

Table E-15: The Scores of /θ/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Subset Training

Onset Subset												
θ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	6.25	12.50	12.50	0.00	6.25	6.25	18.75	6.25	12.50	0.00	81.25	8.13
Training 1	18.75	43.75	56.25	43.75	31.25	31.25	62.50	6.25	25.00	6.25	325.00	32.50
Training 2	25.00	62.50	68.75	68.75	12.50	62.50	56.25	31.25	18.75	12.50	418.75	41.88
Training 3	56.25	50.00	68.75	62.50	25.00	81.25	56.25	31.25	37.50	56.25	525.00	52.50
Training 4	75.00	68.75	43.75	68.75	56.25	75.00	68.75	31.25	31.25	18.75	537.50	53.75
Training 5	87.50	81.25	56.25	62.50	81.25	81.25	62.50	50.00	50.00	43.75	656.25	65.63
Training 6	68.75	68.75	50.00	75.00	56.25	62.50	56.25	31.25	31.25	25.00	525.00	52.50
Training 7	81.25	81.25	62.50	62.50	43.75	43.75	62.50	62.50	31.25	25.00	556.25	55.63
Posttest Per	37.50	18.75	31.25	0.00	37.50	43.75	56.25	37.50	12.50	0.00	275.00	27.50

Table E-16: The Scores of /ð/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Subset Training

Onset Subset												
ð												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	12.50	12.50	12.50	25.00	18.75	43.75	31.25	18.75	37.50	25.00	237.50	23.75
Training 1	31.25	62.50	33.25	37.50	37.50	43.75	50.00	62.50	6.25	62.50	427.00	42.70
Training 2	62.50	37.50	37.50	43.75	31.25	31.25	62.50	43.75	18.75	56.25	425.00	42.50
Training 3	50.00	43.75	31.25	31.25	50.00	68.75	56.25	37.50	43.75	56.25	468.75	46.88
Training 4	50.00	43.75	31.25	43.75	50.00	56.25	56.25	43.75	37.50	43.75	456.25	45.63
Training 5	50.00	56.25	68.75	31.25	68.75	81.25	56.25	31.25	43.75	68.75	556.25	55.63
Training 6	43.75	43.75	62.50	43.75	56.25	62.50	62.50	37.50	31.25	56.25	500.00	50.00
Training 7	56.25	50.00	81.25	37.50	62.50	62.50	68.75	37.50	31.25	75.00	562.50	56.25
Posttest Per	31.25	25.00	50.00	12.50	37.50	43.75	25.00	25.00	31.25	37.50	318.75	31.88

Table E-17: The Average Scores of 10 Learners in the Pretest and the Posttest Perception and the 7-session Onset Subset Training

Procedure	Onset Subset															
	Average Scores of 10 Learners															
	b	d	g	k	l	p	ɹ	s	t	v	w	z	tʃ	ʃ	θ	ð
Pretest Perception	67.50	66.88	78.75	81.25	48.13	86.88	74.38	43.13	74.38	34.38	58.75	61.25	56.25	43.13	8.13	23.75
Training 1										69.38				88.75	32.50	42.70
Training 2										80.00				94.38	41.88	42.50
Training 3										86.25				93.75	52.50	46.88
Training 4										86.88				90.00	53.75	45.63
Training 5										90.63				90.63	65.63	55.63
Training 6										93.75				91.88	52.50	50.00
Training 7										93.75				93.13	55.63	56.25
Posttest Perception	67.50	59.38	86.88	81.25	54.38	96.25	80.00	37.50	77.50	66.25	42.50	56.88	58.75	51.25	27.50	31.88

Appendix F: The Scores of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Table F-1: The Scores of /b/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
b											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	56.25	12.50	62.50	18.75	31.25	6.25	37.50	37.50	12.50	275.00	30.56
Training 1	75.00	25.00	62.50	50.00	43.75	18.75	25.00	43.75	18.75	362.50	40.28
Training 2	93.75	62.50	50.00	56.25	31.25	43.75	56.25	87.50	12.50	493.75	54.86
Training 3	81.25	62.50	56.25	62.50	56.25	62.50	81.25	68.75	43.75	575.00	63.89
Training 4	81.25	68.75	75.00	62.50	56.25	68.75	56.25	75.00	31.25	575.00	63.89
Training 5	93.75	87.50	93.75	68.75	50.00	87.50	87.50	81.25	56.25	706.25	78.47
Training 6	87.50	81.25	75.00	68.75	56.25	62.50	81.25	75.00	31.25	618.75	68.75
Training 7	93.75	93.75	87.50	75	62.50	62.50	68.75	93.75	50.00	687.50	76.39
Posttest Per	93.75	87.50	93.75	62.50	56.25	75.00	87.50	81.25	31.25	668.75	74.31

Table F-2: The Scores of /d/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
d											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	93.75	81.25	81.25	75.00	50.00	37.50	68.75	50.00	50.00	587.50	65.28
Training 1	93.75	81.25	100	75.00	56.25	87.50	68.75	68.75	37.5	668.75	74.31
Training 2	93.75	100	100	100	62.50	81.25	68.75	87.50	31.25	725.00	80.56
Training 3	100	93.75	100	100	68.75	100	93.75	100	50.00	806.25	89.58
Training 4	100	100	100	100	87.50	100	87.50	100	68.75	843.75	93.75
Training 5	100	100	100	100	68.75	93.75	81.25	100	62.5	806.25	89.58
Training 6	100	100	100	93.75	87.50	100	100	100	87.50	868.75	96.53
Training 7	100	100	100	100	81.25	100	93.75	93.75	100	868.75	96.53
Posttest Per	93.75	100	93.75	100	100	87.50	93.75	87.50	93.75	850.00	94.44

Table F-3: The Scores of /f/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
f											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	93.75	81.25	62.50	31.25	12.50	87.50	75.00	6.25	25.00	475.00	52.78
Training 1	68.75	100	62.50	50.00	43.75	87.50	56.25	31.25	37.5	537.50	59.72
Training 2	68.75	100	68.75	75.00	50.00	93.75	37.50	31.25	25.00	550.00	61.11
Training 3	100	100	68.75	62.50	43.75	93.75	68.75	18.75	18.75	575.00	63.89
Training 4	87.50	100	93.75	50.00	62.50	100	87.50	18.75	75.00	675.00	75.00
Training 5	62.50	100	81.25	56.25	56.25	100	81.25	50.00	68.75	656.25	72.92
Training 6	75.00	81.25	81.25	56.25	62.50	81.25	56.25	25.00	37.5	556.25	61.81
Training 7	62.50	100	75.00	62.50	31.25	81.25	50.00	31.25	43.75	537.50	59.72
Posttest Per	68.75	100	87.50	81.25	37.50	87.50	56.25	6.25	68.75	593.75	65.97

Table F-4: The Scores of /g/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
g											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	50.00	18.75	43.75	18.75	31.25	12.50	25.00	43.75	6.25	250.00	27.78
Training 1	68.75	18.75	43.75	31.25	37.50	0.00	18.75	62.50	6.25	287.50	31.94
Training 2	81.25	43.75	62.50	93.75	75.00	0.00	43.75	100	6.25	506.25	56.25
Training 3	87.50	31.25	43.75	87.50	68.75	0.00	75.00	87.50	25.00	506.25	56.25
Training 4	75.00	68.75	62.50	87.50	68.75	0.00	68.75	93.75	50.00	575.00	63.89
Training 5	81.25	87.50	56.25	81.25	81.25	31.25	75.00	87.50	68.75	650.00	72.22
Training 6	75.00	93.75	68.75	81.25	56.25	43.75	75.00	81.25	62.50	637.50	70.83
Training 7	81.25	93.75	81.25	75.00	56.25	75	93.75	100	62.50	718.75	79.86
Posttest Per	68.75	68.75	62.50	56.25	56.25	56.25	75.00	75.00	43.75	562.50	62.50

Table F-5: The Scores of /k/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
k											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	87.50	75.00	62.50	93.75	43.75	81.25	81.25	62.50	37.50	625.00	69.44
Training 1	93.75	100	81.25	93.75	62.50	87.5	75.00	62.50	62.50	718.75	79.86
Training 2	100	100	100	56.25	43.75	93.75	37.50	50.00	87.50	668.75	74.31
Training 3	93.75	100	93.75	87.50	43.75	100	68.75	75.00	93.75	756.25	84.03
Training 4	87.50	100	87.50	93.75	56.25	93.75	50.00	62.50	93.75	725.00	80.56
Training 5	100	100	81.25	100	50.00	81.25	31.25	81.25	93.75	718.75	79.86
Training 6	100	100	87.50	87.50	50.00	81.25	50.00	87.50	87.50	731.25	81.25
Training 7	100	100	100	93.75	50.00	87.50	68.75	87.50	100	787.50	87.50
Posttest Per	87.50	93.75	93.75	87.50	75.00	93.75	56.25	81.25	81.25	750.00	83.33

Table F-6: The Scores of /l/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
l											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	56.25	37.50	81.25	43.75	37.50	62.50	75.00	43.75	50.00	487.50	54.17
Training 1	68.75	50.00	68.75	43.75	0.00	43.75	68.75	25.00	18.75	387.50	43.06
Training 2	68.75	43.75	81.25	56.25	6.25	43.75	100	37.50	43.75	481.25	53.47
Training 3	62.50	50.00	81.25	68.75	12.50	37.50	87.50	62.50	62.50	525.00	58.33
Training 4	68.75	50.00	100	62.50	6.25	43.75	87.50	62.50	75.00	556.25	61.81
Training 5	56.25	43.75	93.75	81.25	31.25	31.25	87.50	56.25	75.00	556.25	61.81
Training 6	68.75	50.00	93.75	75.00	0.00	31.25	100	81.25	75.00	575.00	63.89
Training 7	62.50	50.00	100	87.50	37.50	50.00	100	68.75	81.25	637.50	70.83
Posttest Per	56.25	43.75	93.75	93.75	31.25	68.75	93.75	68.75	81.25	631.25	70.14

Table F-7: The Scores of /p/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
p											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	100	93.75	93.75	75.00	25.00	93.75	81.25	56.25	18.75	637.50	70.83
Training 1	93.75	100	100	93.75	50.00	87.50	75.00	87.50	50.00	737.50	81.94
Training 2	75.00	93.75	100	87.50	31.25	100	81.25	81.25	75.00	725.00	80.56
Training 3	87.50	100	93.75	93.75	25.00	100	81.25	100	87.50	768.75	85.42
Training 4	87.50	100	93.75	87.50	31.25	100	87.50	100	93.75	781.25	86.81
Training 5	93.75	100	100	87.50	25.00	93.75	87.50	93.75	87.50	768.75	85.42
Training 6	87.50	100	93.75	100	25.00	87.50	87.50	93.75	87.50	762.50	84.72
Training 7	100	93.75	100	100	25.00	100	100	100	100	818.75	90.97
Posttest Per	87.50	87.50	87.50	81.25	12.50	93.75	75.00	75.00	75.00	675.00	75.00

Table F-8: The Scores of /ɹ/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
ɹ											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	87.50	100	100	50.00	18.75	37.50	100	18.75	37.50	550.00	61.11
Training 1	75.00	100	81.25	87.50	0.00	62.50	62.50	62.50	25.00	556.25	61.81
Training 2	81.25	93.75	100	87.50	0.00	93.75	68.75	50.00	31.25	606.25	67.36
Training 3	75.00	100	87.50	68.75	0.00	81.25	87.50	43.75	68.75	612.50	68.06
Training 4	100	100	100	56.25	0.00	100	87.50	43.75	93.75	681.25	75.69
Training 5	93.75	100	87.50	62.50	0.00	100	81.25	75.00	93.75	693.75	77.08
Training 6	81.25	100	100	31.25	12.50	100	93.75	31.25	81.25	631.25	70.14
Training 7	87.50	100	100	81.25	6.25	93.75	93.75	68.75	93.75	725.00	80.56
Posttest Per	100	100	93.75	43.75	6.25	93.75	93.75	75.00	81.25	687.50	76.39

Table F-9: The Scores of /s/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
s											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	43.75	50.00	43.75	37.50	31.25	6.25	68.75	12.50	37.50	331.25	36.81
Training 1	62.50	56.25	12.50	56.25	25.00	68.75	37.50	62.50	43.75	425.00	47.22
Training 2	18.75	18.75	31.25	68.75	31.25	81.25	68.75	87.50	81.25	487.50	54.17
Training 3	43.75	56.25	25.00	81.25	43.75	87.50	75.00	75.00	93.75	581.25	64.58
Training 4	50.00	87.50	50.00	81.25	62.50	81.25	68.75	93.75	81.25	656.25	72.92
Training 5	75.00	75.00	68.75	87.50	68.75	100	62.50	87.50	75.00	700.00	77.78
Training 6	56.25	93.75	62.50	87.50	62.50	81.25	62.50	75.00	75.00	656.25	72.92
Training 7	62.50	100	68.75	68.75	75.00	68.75	68.75	81.25	93.75	687.50	76.39
Posttest Per	75.00	50.00	31.25	68.75	56.25	62.50	62.50	75.00	68.75	550.00	61.11

Table F-10: The Scores of /t/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
t											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	68.75	87.50	62.50	62.50	18.75	50.00	37.50	37.50	25.00	450.00	50.00
Training 1	93.75	87.50	87.50	87.50	25.00	75.00	18.75	100	37.50	612.50	68.06
Training 2	100	87.50	100	87.50	25.00	50.00	12.50	87.50	37.50	587.50	65.28
Training 3	100	100	100	100	25.00	62.50	50.00	100	56.25	693.75	77.08
Training 4	100	100	100	100	25.00	100	81.25	100	87.50	793.75	88.19
Training 5	100	100	93.75	100	50.00	87.50	75.00	100	75.00	781.25	86.81
Training 6	100	100	93.75	100	75.00	81.25	87.50	100	93.75	831.25	92.36
Training 7	100	87.50	100	100	87.50	81.25	81.25	93.75	100	831.25	92.36
Posttest Per	93.75	100	100	100	68.75	93.75	87.50	100	87.50	831.25	92.36

Table F-11: The Scores of /v/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
v											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	50.00	18.75	56.25	25.00	18.75	18.75	50.00	37.50	43.75	318.75	35.42
Training 1	6.25	12.50	18.75	0.00	0.00	0.00	43.75	0.00	12.50	93.75	10.42
Training 2	31.25	43.75	25.00	0.00	6.25	0.00	56.25	18.75	25.00	206.25	22.92
Training 3	25.00	31.25	43.75	0.00	12.50	0.00	18.75	12.50	25.00	168.75	18.75
Training 4	43.75	12.50	37.50	6.25	6.25	0.00	6.25	18.75	25.00	156.25	17.36
Training 5	50.00	31.25	37.50	0.00	12.50	0.00	25.00	18.75	25.00	200.00	22.22
Training 6	50.00	25.00	43.75	0.00	6.25	0.00	37.50	25.00	31.25	218.75	24.31
Training 7	75.00	31.25	31.25	6.25	25.00	0.00	18.75	12.50	25.00	225.00	25.00
Posttest Per	56.25	18.75	37.50	0.00	31.25	25.00	25.00	18.75	50.00	262.50	29.17

Table F-12: The Scores of /z/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
z											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	37.50	18.75	12.50	6.25	0.00	6.25	12.50	6.25	0.00	100.00	11.11
Training 1	37.50	37.50	37.50	25.00	0.00	18.75	37.50	56.25	18.75	268.75	29.86
Training 2	56.25	68.75	43.75	0.00	0.00	25.00	62.50	75.00	18.75	350.00	38.89
Training 3	56.25	93.75	62.50	31.25	0.00	37.50	56.25	68.75	43.75	450.00	50.00
Training 4	37.50	100	75.00	18.75	0.00	50.00	56.25	75.00	43.75	456.25	50.69
Training 5	50.00	93.75	68.75	0.00	0.00	56.25	81.25	68.75	50.00	468.75	52.08
Training 6	68.75	100	75.00	6.25	0.00	37.50	75.00	62.50	75.00	500.00	55.56
Training 7	68.75	100	87.50	18.75	0.00	50.00	81.25	62.50	68.75	537.50	59.72
Posttest Per	75.00	68.75	37.50	12.50	0.00	31.25	43.75	25.00	50.00	343.75	38.19

Table F-13: The Scores of /tʃ/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
tʃ											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	68.75	68.75	62.50	75.00	37.50	62.50	81.25	37.50	43.75	537.50	59.72
Training 1	87.50	87.50	87.50	56.25	62.50	68.75	93.75	87.50	37.50	668.75	74.31
Training 2	87.50	62.50	87.50	68.75	62.50	68.75	93.75	62.50	93.75	687.50	76.39
Training 3	93.75	68.75	100	81.25	75.00	75.00	100	75.00	87.50	756.25	84.03
Training 4	87.50	100	100	93.75	81.25	68.75	100	68.75	81.25	781.25	86.81
Training 5	81.25	68.75	100	81.25	81.25	93.75	100	100	75.00	781.25	86.81
Training 6	81.25	87.50	100	93.75	68.75	81.25	100.00	62.50	62.50	737.50	81.94
Training 7	75.00	68.75	100	81.25	100	93.75	100	81.52	68.75	769.02	85.45
Posttest Per	62.50	100	100	93.75	62.50	68.75	81.25	56.25	62.50	687.50	76.39

Table F-14: The Scores of /ʃ/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
ʃ											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	18.75	31.25	12.50	25.00	12.50	12.50	12.50	18.75	25.00	168.75	18.75
Training 1	37.5	18.75	25.00	12.50	6.25	12.50	43.75	68.75	43.75	268.75	29.86
Training 2	62.50	18.75	75.00	31.25	12.50	12.50	50.00	81.25	31.25	375.00	41.67
Training 3	50.00	18.75	87.50	37.50	18.75	12.50	87.50	75.00	37.50	425.00	47.22
Training 4	81.25	0.00	81.25	6.25	25.00	18.75	81.25	75.00	43.75	412.50	45.83
Training 5	87.50	6.25	87.50	31.25	0.00	12.50	87.50	87.50	62.50	462.50	51.39
Training 6	87.50	37.50	68.75	12.50	12.50	18.75	100.00	81.25	50.00	468.75	52.08
Training 7	93.75	12.50	81.25	43.75	0.00	6.25	100	93.75	93.75	525.00	58.33
Posttest Per	75.00	0.00	68.75	6.25	0.00	18.75	100	68.75	43.75	381.25	42.36

Table F-15: The Scores of /θ/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
θ											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	6.25	6.25	25.00	6.25	6.25	18.75	12.50	0.00	18.75	100.00	11.11
Training 1	6.25	0.00	43.75	0.00	0.00	18.75	6.25	6.25	6.25	87.50	9.72
Training 2	31.25	0.00	12.50	0.00	0.00	6.25	31.25	0.00	0.00	81.25	9.03
Training 3	25.00	0.00	12.50	6.25	0.00	0.00	6.25	43.75	0.00	93.75	10.42
Training 4	12.50	0.00	25.00	6.25	0.00	0.00	6.25	62.50	6.25	118.75	13.19
Training 5	12.50	0.00	31.25	6.25	0.00	0.00	31.25	56.25	0.00	137.50	15.28
Training 6	6.25	0.00	18.75	0.00	6.25	0.00	37.50	37.50	43.75	150.00	16.67
Training 7	0.00	0.00	25.00	0.00	6.25	0.00	50.00	68.75	62.50	212.50	23.61
Posttest Per	18.75	0.00	25.00	6.25	12.50	6.25	25.00	43.75	31.25	168.75	18.75

Table F-16: The Scores of /ð/ of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

Coda Fullset											
ð											
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Sum of 9 Learners' Scores	Average Scores of 9 Learners
Pretest Perception	0.00	0.00	25.00	6.25	12.50	18.75	18.75	0.00	6.25	87.50	9.72
Training 1	0.00	6.25	18.75	0.00	6.25	12.50	6.25	6.25	6.25	62.50	6.94
Training 2	6.25	0.00	25.00	6.25	6.25	12.50	0.00	25.00	0.00	81.25	9.03
Training 3	12.50	0.00	37.50	6.25	25.00	0.00	31.25	25.00	0.00	137.50	15.28
Training 4	6.25	0.00	25.00	0.00	18.75	0.00	25.00	18.75	18.75	112.50	12.50
Training 5	6.25	0.00	37.50	0.00	6.25	0.00	37.50	12.50	68.75	168.75	18.75
Training 6	12.50	0.00	25.00	0.00	18.75	12.50	62.50	12.50	25.00	168.75	18.75
Training 7	12.50	0.00	25.00	12.50	25.00	0.00	56.25	25.00	37.50	193.75	21.53
Posttest Per	12.50	0.00	0.00	0.00	0.00	12.50	25.00	6.25	25.00	81.25	9.03

Table F-17: The Average Scores of 9 Learners in the Pretest and the Posttest Perception and the 7-session Coda Fullset Training

	Coda Fullset															
Procedure	Average Scores of 9 Learners															
	b	d	f	g	k	l	p	ɹ	s	t	v	z	tʃ	ʃ	θ	ð
Pretest Perception	30.56	65.28	52.78	27.78	69.44	54.17	70.83	61.11	36.81	50.00	35.42	11.11	59.72	18.75	11.11	9.72
Training 1	40.28	74.31	59.72	31.94	79.86	43.06	81.94	61.81	47.22	68.06	10.42	29.86	74.31	29.86	9.72	6.94
Training 2	54.86	80.56	61.11	56.25	74.31	53.47	80.56	67.36	54.17	65.28	22.92	38.89	76.39	41.67	9.03	9.03
Training 3	63.89	89.58	63.89	56.25	84.03	58.33	85.42	68.06	64.58	77.08	18.75	50.00	84.03	47.22	10.42	15.28
Training 4	63.89	93.75	75.00	63.89	80.56	61.81	86.81	75.69	72.92	88.19	17.36	50.69	86.81	45.83	13.19	12.50
Training 5	78.47	89.58	72.92	72.22	79.86	61.81	85.42	77.08	77.78	86.81	22.22	52.08	86.81	51.39	15.28	18.75
Training 6	68.75	96.53	61.81	70.83	81.25	63.89	84.72	70.14	72.92	92.36	24.31	55.56	81.94	52.08	16.67	18.75
Training 7	76.39	96.53	59.72	79.86	87.50	70.83	90.97	80.56	76.39	92.36	25.00	59.72	85.45	58.33	23.61	21.53
Posttest Perception	74.31	94.44	65.97	62.50	83.33	70.14	75.00	76.39	61.11	92.36	29.17	38.19	76.39	42.36	18.75	9.03

Appendix G: The Scores of 10 Learners in the Pretest and the Posttest Perception and the 7-session Coda Subset Training

Table G-1: The Scores of /b/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Coda Subset Training

Coda Subset												
b												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	50.00	18.75	50.00	37.50	25.00	12.50	12.50	50.00	50.00	18.75	325.00	32.50
Training 1	100	81.25	81.25	100	93.75	56.25	56.25	50.00	93.75	100	812.50	81.25
Training 2	100	87.50	50.00	100	93.75	50.00	81.25	68.75	100	100	831.25	83.13
Training 3	100	100	87.50	100	100	43.75	87.50	87.50	93.75	100	900.00	90.00
Training 4	100	100	93.75	100	100	43.75	75.00	100	100	100	912.50	91.25
Training 5	100	93.75	75.00	100	100	100	81.25	100	100	100	950.00	95.00
Training 6	100	100	93.75	93.75	100	93.75	75.00	93.75	100	93.75	943.75	94.38
Training 7	100	100	87.50	100	100	93.75	75.00	100	100	100	956.25	95.63
Posttest Per	93.75	50.00	56.25	81.25	62.50	37.50	100	87.50	100	75.00	743.75	74.38

Table G-2: The Scores of /d/ of 10 Learners in the Pretest and the Posttest Perception Coda Subset Training

Coda Subset												
d												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	87.50	50.00	31.25	62.50	50.00	50.00	37.50	50.00	68.75	31.25	518.75	51.88
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	87.50	25.00	56.25	50.00	37.50	43.75	50.00	81.25	93.75	50.00	575.00	57.50

Table G-3: The Scores of /f/ of 10 Learners in the Pretest and the Posttest Perception Coda Subset Training

Coda Subset												
f												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	87.50	12.50	12.50	75	25.00	43.75	12.50	18.75	18.75	75.00	381.25	38.13
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	87.50	18.75	18.75	62.50	25.00	37.50	12.50	31.25	12.50	37.50	343.75	34.38

Table G-4: The Scores of /g/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Coda Subset Training

Coda Subset												
g												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	25.00	25.00	25.00	62.50	18.75	31.25	18.75	31.25	31.25	25.00	293.75	29.38
Training 1	100	50.00	68.75	100	68.75	87.50	37.50	75.00	100	93.75	781.25	78.13
Training 2	100	81.25	93.75	100	81.25	100	93.75	93.75	100	100	943.75	94.38
Training 3	100	75.00	68.75	100	100	100	100	93.75	100	100	937.50	93.75
Training 4	100	93.75	100	100	100	100	100	100	100	100	993.75	99.38
Training 5	100	93.75	100	100	93.75	100	100	100	100	100	987.50	98.75
Training 6	100	87.50	100	100	100	100	100	100	100	100	987.50	98.75
Training 7	100	87.50	100	100	93.75	100	100	100	100	100	981.25	98.13
Posttest Per	50.00	56.25	43.75	75.00	81.25	75.00	87.50	75.00	43.75	93.75	681.25	68.13

Table G-5: The Scores of /k/ of 10 Learners in the Pretest and the Posttest Perception Coda Subset Training

Coda Subset												
k												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	87.50	87.50	56.25	50.00	81.25	81.25	43.75	68.75	81.25	87.50	725.00	72.50
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	75.00	56.25	37.50	50.00	75.00	25.00	43.75	62.50	75.00	31.25	531.25	53.13

Table G-6: The Scores of /l/ of 10 Learners in the Pretest and the Posttest Perception Coda Subset Training

Coda Subset												
l												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	62.50	75.00	25.00	62.50	43.75	56.25	31.25	25.00	75.00	43.75	500.00	50
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	43.75	43.75	50.00	62.50	43.75	50.00	25.00	50.00	68.75	12.50	450.00	45

Table G-7: The Scores of /p/ of 10 Learners in the Pretest and the Posttest Perception Coda Subset Training

Coda Subset												
p												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	81.25	75.00	31.25	81.25	50.00	68.75	56.25	12.50	75.00	87.50	618.75	61.88
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	81.25	62.50	50.00	43.75	50.00	81.25	18.75	43.75	50.00	56.25	537.50	53.75

Table G-8: The Scores of /ɹ/ of 10 Learners in the Pretest and the Posttest Perception Coda Subset Training

Coda Subset												
ɹ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	62.50	81.25	75.00	56.25	87.50	81.25	6.25	37.50	68.75	37.50	593.75	59.38
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	68.75	68.75	81.25	81.25	100	87.50	18.75	43.75	93.75	31.25	675.00	67.50

Table G-9: The Scores of /s/ of 10 Learners in the Pretest and the Posttest Perception Coda Subset Training

Coda Subset												
s												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	75.00	6.25	12.50	81.25	18.75	0.00	0.00	31.25	37.50	0.00	262.50	26.25
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	93.75	12.50	6.25	68.75	37.50	37.50	12.50	31.25	37.50	0.00	337.50	33.75

Table G-10: The Scores of /t/ of 10 Learners in the Pretest and the Posttest Perception Coda Subset Training

Coda Subset												
t												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	81.25	50.00	12.50	62.50	31.25	68.75	12.50	31.25	50.00	12.50	412.50	41.25
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	100	50.00	25.00	56.25	56.25	50.00	12.50	68.75	93.75	37.50	550.00	55

Table G-11: The Scores of /v/ of 10 Learners in the Pretest and the Posttest Perception Coda Subset Training

Coda Subset												
v												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	18.75	50.00	37.50	43.75	18.75	43.75	12.50	50.00	93.75	18.75	387.50	38.75
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	0.00	37.50	31.25	25.00	18.75	12.50	18.75	12.50	43.75	0.00	200.00	20

Table G-12: The Scores of /z/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Coda Subset Training

Coda Subset												
z												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	25.00	0.00	0.00	18.75	6.25	0.00	0.00	12.50	12.50	6.25	81.25	8.13
Training 1	100	37.50	25.00	87.50	81.25	75.00	25.00	56.25	81.25	93.75	662.50	66.25
Training 2	100	81.25	25.00	100	87.50	87.50	50.00	43.75	62.50	81.25	718.75	71.88
Training 3	100	93.75	25.00	93.75	100	93.75	37.50	75.00	68.75	75.00	762.50	76.25
Training 4	100	68.75	37.50	100	100	100	68.75	93.75	62.50	75.00	806.25	80.63
Training 5	93.75	62.50	31.25	100	100	93.75	50.00	100	68.75	62.50	762.50	76.25
Training 6	100	50.00	62.50	100	93.75	100	43.75	87.50	81.25	87.50	806.25	80.63
Training 7	100	68.75	56.25	100	100	100	50.00	81.25	81.25	100	837.50	83.75
Posttest Per	37.50	6.25	12.50	18.75	37.50	25.00	6.25	43.75	37.50	56.25	281.25	28.13

Table G-13: The Scores of /tʃ/ of 10 Learners in the Pretest and the Posttest Perception Coda Subset Training

Coda Subset												
tʃ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	50.00	6.25	25.00	75.00	31.25	31.25	0.00	43.75	87.50	56.25	406.25	40.63
Training 1												
Training 2												
Training 3												
Training 4												
Training 5												
Training 6												
Training 7												
Posttest Per	43.75	12.50	18.75	50.00	37.50	75.00	0.00	56.25	93.75	6.25	393.75	39.38

Table G-14: The Scores of /ʃ/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Coda Subset Training

Coda Subset												
ʃ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	31.25	6.25	18.75	37.50	6.25	25.00	25.00	12.50	18.75	6.25	187.50	18.75
Training 1	93.75	37.50	43.75	87.50	56.25	68.75	50.00	81.25	87.50	37.50	643.75	64.38
Training 2	100	75.00	31.25	100	87.50	87.50	68.75	68.75	100	37.50	756.25	75.63
Training 3	100	75.00	56.25	100	87.50	81.25	68.75	56.25	100	87.50	812.50	81.25
Training 4	100	25.00	50.00	93.75	100	75.00	75.00	68.75	100	93.75	781.25	78.13
Training 5	100	81.25	68.75	100	100	100	62.50	81.25	100	100	893.75	89.38
Training 6	100	25.00	50.00	100	100	100	87.50	93.75	100	100	856.25	85.63
Training 7	100	50.00	56.25	100	100	100	87.50	87.50	100	100	881.25	88.13
Posttest Per	75.00	25.00	25.00	68.75	62.50	18.75	0.00	25.00	18.75	62.50	381.25	38.13

Table G-15: The Scores of /θ/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Coda Subset Training

Coda Subset												
θ												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	6.25	0.00	0.00	12.50	0.00	12.50	6.25	6.25	25.00	12.50	81.25	8.13
Training 1	75.00	18.75	12.50	62.50	43.75	31.25	37.50	25.00	62.50	0.00	368.75	36.88
Training 2	87.50	75.00	12.50	56.25	37.50	43.75	31.25	18.75	50.00	25.00	437.50	43.75
Training 3	68.75	56.25	6.25	62.50	31.25	12.50	37.50	37.50	62.50	18.75	393.75	39.38
Training 4	81.25	12.50	0.00	68.75	56.25	37.50	37.50	37.50	68.75	18.75	418.75	41.88
Training 5	87.50	43.75	37.50	75.00	50.00	37.50	68.75	37.50	75.00	31.25	543.75	54.38
Training 6	68.75	25.00	12.50	62.50	43.75	25.00	87.50	62.50	56.25	31.25	475.00	47.50
Training 7	87.50	75.00	18.75	68.75	56.25	37.50	68.75	56.25	68.75	43.75	581.25	58.13
Posttest Per	50.00	12.50	6.25	31.25	31.25	6.25	6.25	31.25	37.50	31.25	243.75	24.38

Table G-16: The Scores of /ð/ of 10 Learners in the Pretest and the Posttest Perception and the 7-session Coda Subset Training

Coda Subset												
ð												
Procedure	Learner 1	Learner 2	Learner 3	Learner 4	Learner 5	Learner 6	Learner 7	Learner 8	Learner 9	Learner 10	Sum of 10 Learners' Scores	Average Scores of 10 Learners
Pretest Perception	0.00	0.00	0.00	6.25	0.00	0.00	0.00	6.25	18.75	12.50	43.75	4.38
Training 1	37.50	12.50	6.25	37.50	25.00	50.00	18.75	25.00	50.00	18.75	281.25	28.13
Training 2	31.25	25.00	12.50	56.25	18.75	43.75	6.25	25.00	43.75	37.50	300.00	30.00
Training 3	43.75	50.00	12.50	37.50	18.75	43.75	25.00	25.00	43.75	68.75	368.75	36.88
Training 4	50.00	6.25	0.00	31.25	25.00	31.25	25.00	37.50	50.00	50.00	306.25	30.63
Training 5	50.00	31.25	31.25	56.25	37.50	25.00	37.50	37.50	62.50	43.75	412.50	41.25
Training 6	37.50	6.25	18.75	50.00	25.00	43.75	37.50	31.25	50.00	50.00	350.00	35.00
Training 7	62.50	43.75	31.25	56.25	50.00	31.25	43.75	37.50	50.00	56.25	462.50	46.25
Posttest Per	12.50	6.25	0.00	31.25	25.00	6.25	0.00	18.75	18.75	43.75	162.50	16.25

Table G-17: The average scores of 10 learners in the Pretest and the Posttest Perception and the 7-session Coda Subset Training

Procedure	Coda Subset															
	Average Scores of 10 Learners															
	b	d	f	g	k	l	p	ɹ	s	t	v	z	tʃ	ʃ	θ	ð
Pretest Perception	32.50	51.88	38.13	29.38	72.50	50.00	61.88	59.38	26.25	41.25	38.75	8.13	40.63	18.75	8.13	4.38
Training 1	81.25			78.13								66.25		64.38	36.88	28.13
Training 2	83.13			94.38								71.88		75.63	43.75	30.00
Training 3	90.00			93.75								76.25		81.25	39.38	36.88
Training 4	91.25			99.38								80.63		78.13	41.88	30.63
Training 5	95.00			98.75								76.25		89.38	54.38	41.25
Training 6	94.38			98.75								80.63		85.63	47.50	35.00
Training 7	95.63			98.13								83.75		88.13	58.13	46.25
Posttest Perception	74.38	57.50	34.38	68.13	53.13	45.00	53.75	67.50	33.75	55.00	20.00	28.13	39.38	38.13	24.38	16.25

CURRICULUM VITAE

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Personal

Place and Date of Birth: Bangkok, Thailand, May 24th, 1982
Nationality: Thai

Education

2015	Ph.D., Linguistics, Department of Linguistics, University of Wisconsin-Milwaukee, USA Dissertation: *Perception Training of Thai Learners: American English Consonants and Vowels* Committee chair: Professor Hanyong Park
2012	Linguistics Qualifying Exam (MA), Department of Linguistics, University of Wisconsin-Milwaukee, USA MA paper: *The Comparison of wh-expressions in Thai and English* Committee chair: Professor Garry W. Davis
2006	M.A., English as an International Language (Interdisciplinary/ International Program), Chulalongkorn University, Bangkok, Thailand Advisor: Professor Chansonglod Gajaseni
2004	B.Ed., Secondary Education: English - French (1st class honours), Chulalongkorn University, Bangkok, Thailand Advisor: Professor Vanee Limpisvasti

Experience

Fall 2010 – Spring 2014, Spring 2015

Graduate teaching assistant (Discussion instructor), Linguistics 100 and 210 for undergraduates, Department of Linguistics, University of Wisconsin-Milwaukee

Diversity of Human Language (Linguis 100):

- Fall 2010 and Spring 2011: Under the supervision of Professor Ahrong Lee
- Fall 2011 and Spring 2012: Under the supervision of Professor Carolyn Zafra
- Fall 2013 and Spring 2014: Under the supervision of Professor Fred Eckman

Power of Words (Linguis 210):

- Fall 2012, Spring 2013 and Spring 2015: Under the supervision of Professor Sandra Pucci

Fall 2014	Graduate teaching assistant (Full course responsibility), Linguistics 210 (online) for undergraduates, Department of Linguistics, University of Wisconsin-Milwaukee
2009 – 2010, Summer 2014	Instructor, English for undergraduates and graduates, Department of Foreign Languages, Kasetsart University, Bangkok, Thailand
2008 – 2009	Thai language instructor, Thai for undergraduates, Department of Foreign Languages and Literature, University of Wisconsin-Milwaukee
2006 – 2008	Instructor, English for undergraduates and graduates, Department of Foreign Languages, Kasetsart University, Bangkok, Thailand
2006	Research assistant, Trade Liberalization in Higher Education: Case Study of Thailand University System, Center for European Studies, Chulalongkorn University, Bangkok, Thailand
2003	Trainee teacher, Secondary Education: English for grade 8 and French for grade 10 students, Bhuddhajak School, Bangkok, Thailand

Awards and Grants

2010 – present	Graduate Teaching Assistantship, Department of Linguistics, University of Wisconsin-Milwaukee
Fall 2014, Spring 2015	Chancellor's Graduate Student Awards, Department of Linguistics, University of Wisconsin-Milwaukee
Spring 2014	Student Transportation Subsidy Grant, the Acoustical Society of America
Fall 2012, Fall 2013, Spring 2014	Graduate Student Travel Grants, Department of Linguistics, University of Wisconsin-Milwaukee
Spring 2013, Summer 2013, Fall 2013	Graduate Student Travel Awards, Graduate School, University of Wisconsin-Milwaukee

2008 – 2009	Fulbright FLTA Program at Department of Foreign Languages and Literature, University of Wisconsin-Milwaukee, United States Department of State Bureau of Educational and Cultural Affairs (ECA) administered by the Institute of International Education (IIE) and Thailand-United States Educational Foundation (TUSEF)
2003	Academic Achievement Award, The Shell Company of Thailand Limited, Bangkok, Thailand
2003	The Best Teaching in French Award, Faculty of Education, Chulalongkorn University, Bangkok, Thailand
2002	Third Place in Video Quiz Contest Presented by Her Royal Highness Princess Galyani Vadhana, The Association of Thai Professors Teaching French Language
1997	Thai Universal Cultural Exchange Program to New Zealand, Piopio College, Piopio, New Zealand

Research Interests
Phonetics, Phonology, Psycholinguistics, Second Language Acquisition, Thai

Publications
Working Papers
Lerdpaisalwong, S., & Gajaseni, C. (2006). A study of the use of language learning strategies by high and low language learning achievers among first year education students at Chulalongkorn University. *Working Papers in English as an International Language, 2*, 154-168.

Papers and Work in Progress
Perception Training of Thai Learners: American English Consonants and Vowels

Production and Perception of English Coda Stops by L1-Thai Learners of English

Tone Neutralization in Thai Disyllables of the Type CV(ʔ)

False Phonological Memories in Thai

Conference Presentations & Posters

May 2014	“The Perception of Postvocalic English Stops in Diphthongs and Monophthongs Using Gating Experiment,” The 167th Meeting of the Acoustical Society of America, Providence, Rhode Island.

April 2014 — “English Coda Stops by Thai EFLs under the Optimality Theory,” The 2014 SLA Graduate Student Symposium, Madison, Wisconsin.

November 2013 — “Production and Perception of English Coda Stops by L1-Thai Learners of English,” with Hanyong Park, Second Language Research Forum (SLRF 2013), Provo, Utah.

May 2013 — "Tone Neutralization in Thai Disyllables of the Type CV(ʔ)," with Hanyong Park and Garry Davis, 23rd Annual Meeting of the Southeast Asian Linguistics Society (SEALS 23), Bangkok, Thailand.

March 2013 — "The Perception of English Stops in Coda Position by Thai Learners," with Hanyong Park, Mid-Continental Phonetics & Phonology Conference (MidPhon 18), Ann Arbor, Michigan.

October 2012 — "The Production and Perception of English Stops in a Coda Position by Thai Speakers," The 164th Meeting of the Acoustical Society of America, Kansas City, Missouri.

October 2012 — "The Production and Perception of English Stops in a Coda Position by Thai Speakers," with Hanyong Park, Second Language Research Forum (SLRF 2012), Pittsburgh, Pennsylvania.

Workshops

Linguistic Society of America (LSA) 2015 Linguistic Summer Institute, University of Chicago, Chicago, Illinois.

- Articulatory Phonology
- Neuroscience of Language
- Perceptual Dialectology: What have we learned? What’s to be done?
- The Dynamics of Speech Perception

Living in the Acoustic Environment, The Acoustical Society of America School 2014, Providence, Rhode Island.

Second Language Research Forum (SLRF 2013) workshop, Brigham Yong University, Provo, Utah.

- Approaches to Analyzing Speech (Palatometer, Praat and More)
- New Technologies for Conducting Second Language Acquisition Research

Second Language Research Forum (SLRF 2012) workshop, Carnegie Mellon University, Pittsburgh, Pennsylvania.

- Introduction to Discourse Analysis for Second Language Research

Fulbright FLTA workshop 2008, Stanford University, Stanford, California.

- Selecting and/or Adopting Appropriate Materials for the Second Language Classroom
- Technology & Second Language Teaching
- Second Language Teaching & Learning: Course Design, Lesson Planning, Methods, Assessment

Memberships

2012 – present Acoustical Society of America

2012 – present Linguistic Society of America

Institutional Services

University of Wisconsin-Milwaukee, 2010 – 2015

Service to the Department of Linguistics

- **Volunteer,** the 29th Annual Symposium on Arabic Linguistics
- **Organizational committee,** The 2014 Meeting of the Graduate Workshop of the American Midwest and Prairies (GWAMP 2014)
- **Volunteer,** Open House
- **Volunteer,** the 26th Linguistics Symposium: Language Death, Endangerment, Documentation and Revitalization, Department of Linguistics, University of Wisconsin-Milwaukee

Kasetsart University, Bangkok, Thailand, 2006 – 2008 and 2009 - 2010

Service to the Faculty of Humanities

- **Secretary,** Research and Academic Service Committee
- **Member,** Extracurricular Activities Committee
- **Member,** Student Affairs Committee
- **Member,** Cooperative Education Committee
- **Staff member,** Graduation Ceremony
- **Staff member,** Open House

Service to the Department of Foreign Languages

- **Coordinator,** Foundation English Committee
- **Secretary,** Kasetsart University Test Center for Foreign Language
- **Secretary,** Master of Arts Program in English for Specific Purposes (MA-ESP): Regular Program
- **Member,** Quality Insurance Committee
- **Instructor,** Business English for Kasetsart University Undergraduates (One-Day Intensive Course)

Chulalongkorn University, Bangkok, Thailand, 2002 – 2005

Service to the Master of Arts Program in English as an International Language (Interdisciplinary/ International Program)

- **Volunteer,** Chulalongkorn University Academic Fair, English as an International Language: Effective Integration of Language Learning (EIL2)
- **Volunteer,** Open House

Service to the Faculty of Education

- **Staff,** Chulalongkorn University Academic Fair, The Role of Education: Students Solving Social Problems
- **Staff,** International Conference

Activities

Fall 2010 – Spring 2015	President, Thai Student Association at University of Wisconsin-Milwaukee
Spring 2015	Translating an official document for ESL Program, University of Wisconsin-Milwaukee
2014 – 2015	Volunteer, Graduate Student Representative, Department of Linguistics, University of Wisconsin-Milwaukee
2010, 2012 – 2014	Volunteer, Holiday Folk Fair International, International Institute of Wisconsin and Thai-American Association of Milwaukee
2011	Performing a Classical Thai Dance, Cultural Entertainment Night at UWM, Asian Student Union of University of Wisconsin-Milwaukee
2009	Milwaukee's Representative, Thai New Year (Songkran) Beauty Contest 2009, Thai Nurses Association of Illinois and Thai-American Association of Milwaukee, Dhammaram Temple, Chicago, Illinois

Languages

Thai (native), English (fluent), and French (intermediate)

Computer Skills

Microsoft Office: Word, PowerPoint, and Excel
Audacity
Praat
SPSS

References

Will be furnished upon request.